APPENDIX-6

Seismic Diagnosis on Mechanical and Electrical Equipment

Appendix-6.1

Summary of Site Survey

Sheet 1 Condition of Foundation (Mechanical Equipment 1: pump)

Pump is in danger of overturn or sideslip by earthquake if it is not installed properly.
That may cause failure of facility.

Summary of Existing Condition:

Almost all the pumps are fixed to the foundation with foundation bolt firmly and seem to be in good condition. To confirm whether pump is earthquake-resistant, further data is needed such as as-built drawing, shape of foundation bolt, etc. After necessary data is aquired, calculation will be done to check the strength of foundation bolt.

No.1 Reservoir(Yousefabad)

No.1 Reservoir(Yousefabad)

Typical Appearance

Proposed Countermeasure:

No countermeasures will be needed if the pump is confirmed to be earthquake-resistant by calculation. (The calculation is reported Appendix-6.2.)

Sheet 2 Condition of Foundation (Mechanical Equipment 2: tank)

Tank is in danger of overturn or sideslip by earthquake if it is not installed properly.
That may cause failure of facility.

Summary of Existing Condition:

Almost all the surge tanks are fixed to the foundation with foundation bolt firmly and seem to be in good condition. To confirm whether tank is earthquake-resistant, further data is needed such as as-built drawing, shape of foundation bolt, etc. After necessary data is aquired, calculation will be done to check the strength of foundation bolt.

Typical Appearance

Proposed Countermeasure:

No countermeasures will be needed if the surge tank is confirmed to be earthquake-resistant by calculation. (The calculation is reported Appendix-6.2.)

Sheet 3 Chlorine Dosing Equipment

Chlorine cylinder is in danger of movement or sideslip by earthquake if it is not fixed and stored properly. The occurrence of earthquake may lead to gas leakage as well as the failure of facility.

Summary of Existing Condition:

Some cylinders seem to be in danger of movement or sideslip by earthquake. And neutralization equipment is not installed.

No.1 WTP(Jalalie)

No.33 Reservoir(Upper Darband)

No.1 WTP(Jalalie)

Typical Appearance

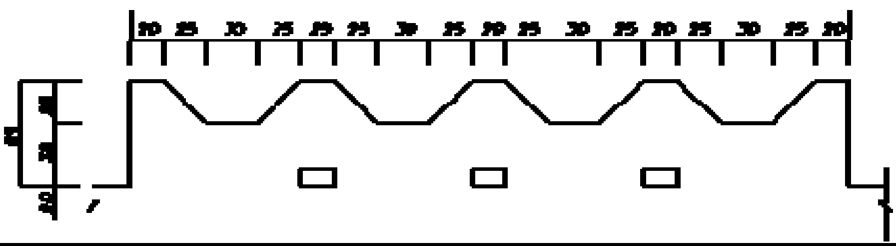
Proposed Countermeasure:

1) Construction of chlorine cylinder storage like No.5 WTP(Lashkarak) and installation of neutralization equipment.

2) Or, change the chlorine dosing system to safer systems such as sodium hypochlorite system.

No.5 WTP(Lashkarak)

No.5 WTP(Lashkarak)

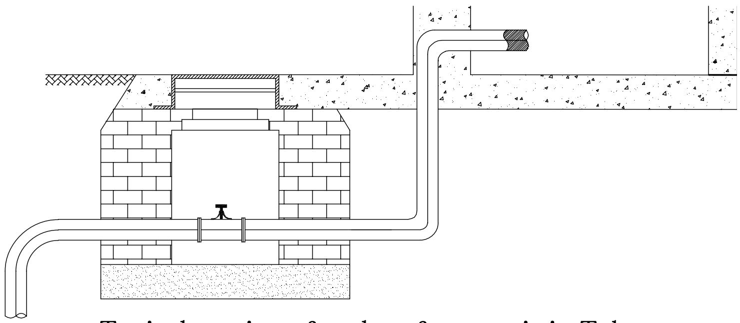


Sheet 4 Installation of Emergency Shut-off Valve

Emergency shut-off valve is necessary for reservoir to prevent secondary disaster and wasting water by leakage.

Summary of Existing Condition:

There is no emergency shut-off valve installed at outlet of reservoir.

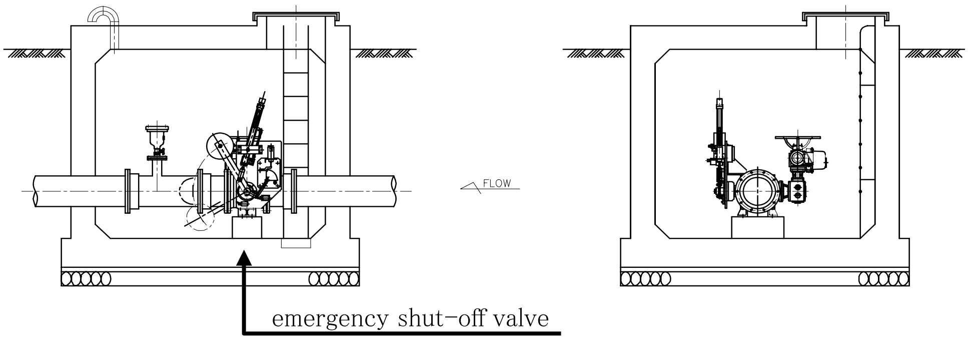


Typical section of outlet of reservoir in Tehran

Typical Appearance

Proposed Countermeasure:

1) Installation of emergency shut-off valve at outlet of reservoir.



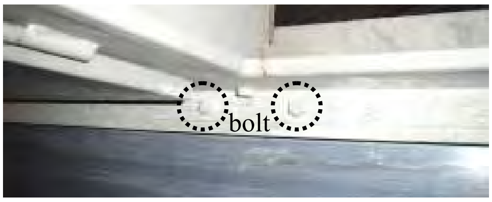
Sheet 5 Condition of Foundation (Electrical Equipment 1: self-standing panel)

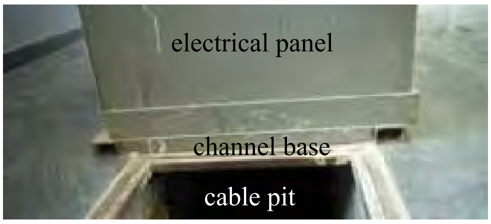
Self-standing panel is in danger of overturn or sideslip by earthquake if it is not installed properly.

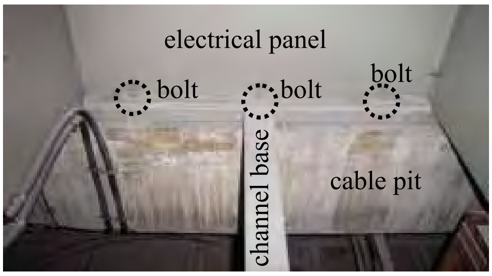
Summary of Existing Condition:

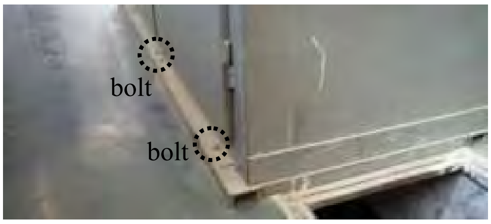
Some electrical panels are fixed to their channel base firmly. But their channel bases don't seem to be fixed to the floor with foundation bolt. <u>To confirm whether those panels are earthquake-resistant or not, further data is needed such as as-bult drawing, shape of foundation bolt, etc.</u> After necessary data is aquired, calculation will be done to check the strength of foundation bolt.

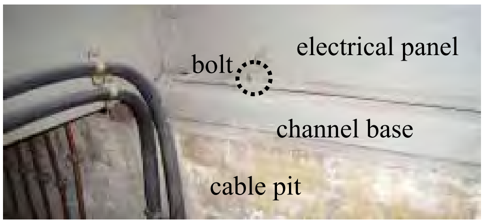
And some electrical panels such as 400V pump panels are not equipped with foundation bolt. They seem to be not earthquake-resistant.











<u>Typical Appearance</u>

Proposed Countermeasure:

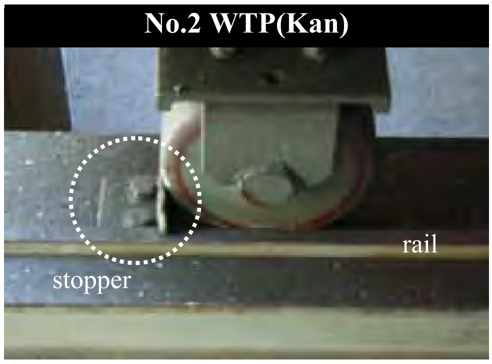
No countermeasures will be needed if the panel is confirmed to be earthquake-resistant by calculation. (The calculation is reported Appendix-6.2.)

Sheet 6 Condition of Foundation (Electrical Equipment 2: transformer)

Transformer is in danger of overturn or sideslip by earthquake if it is not installed properly. That may cause fire as wel as the failure of the facility.

Summary of Existing Condition:

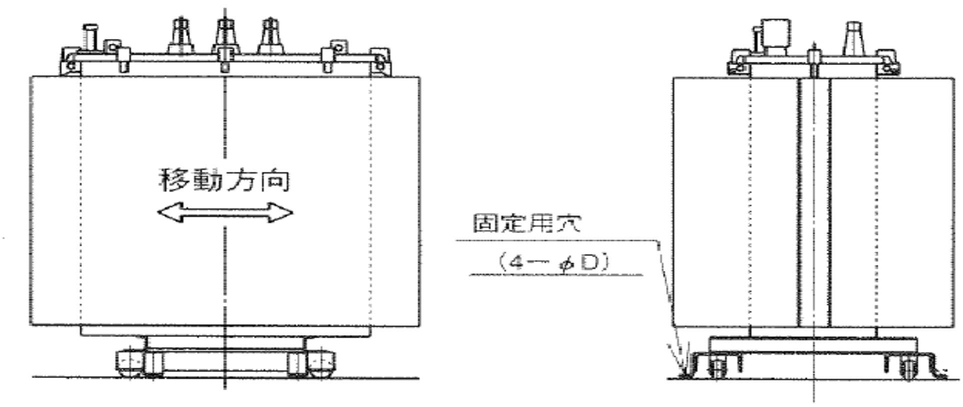
The wheel of transformer is equipped with stopper and rail, but it does not seem to be earthquake-resistant. Because it is not fixed with foundation bolt.



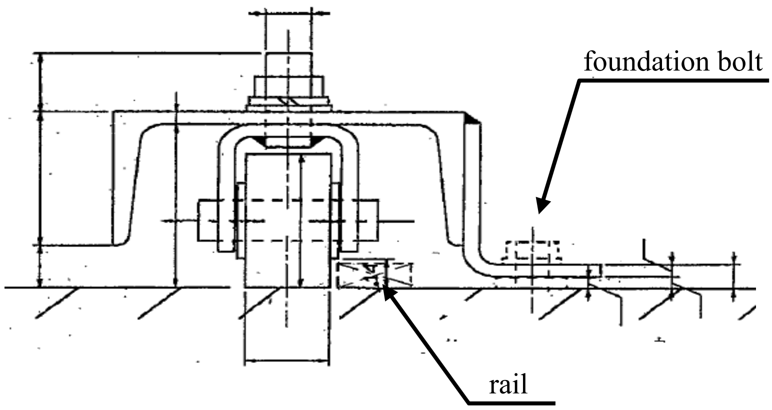
Typical Appearance

Proposed Countermeasure:

1) Fix the transformer by foundation bolt.



Side View **Front View**

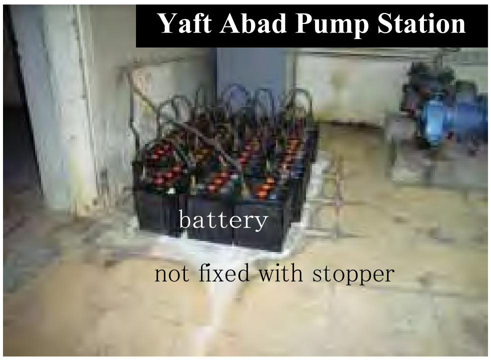


Sheet 7 Condition of Foundation (Electrical Equipment 3: battery)

Battery is in danger of overturn or sideslip by earthquake if it is not installed properly.
It may lead to failure of facility.

Summary of Existing Condition:

Battery is not fixed with stopper or foundaition bolt in almost all of the facilities.
But, the battery at No.1 Reservoir(Yousefabad) is fixed with stopper firmly.



Typical Appearance

Proposed Countermeasure:

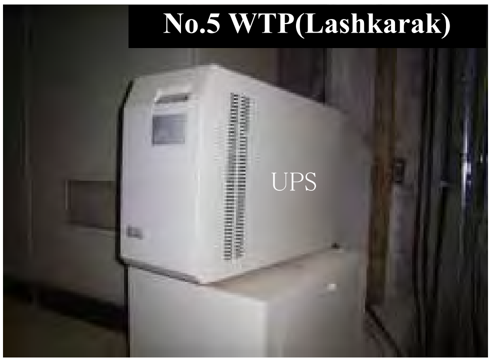
1) Installation of stopper for battery.

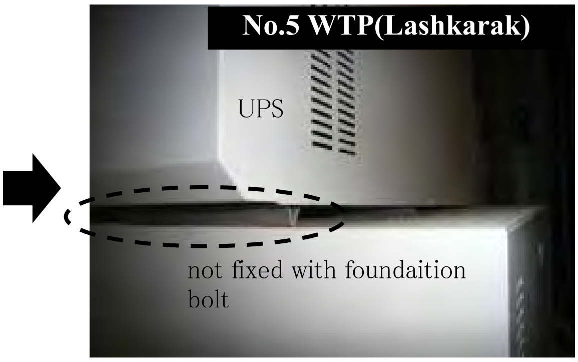
Sheet 8 Condition of Foundation (Electrical Equipment 4: UPS)

UPS (Uninterruptible Power Supply) is in danger of overturn or sideslip by earthquake if it is not installed properly. That may cause failure of facility.

Summary of Existing Condition:

UPS is not fixed with stopper or foundaition bolt in any of the facilities.

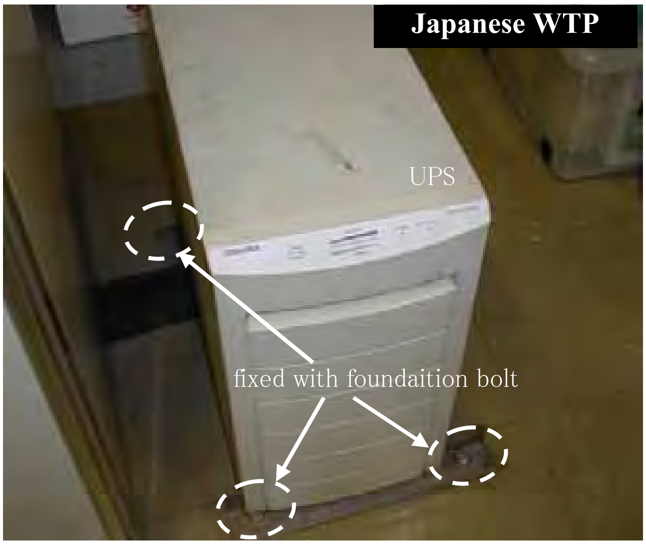




Typical Appearance

Proposed Countermeasure:

1) Installation of foundaition bolt for UPS.

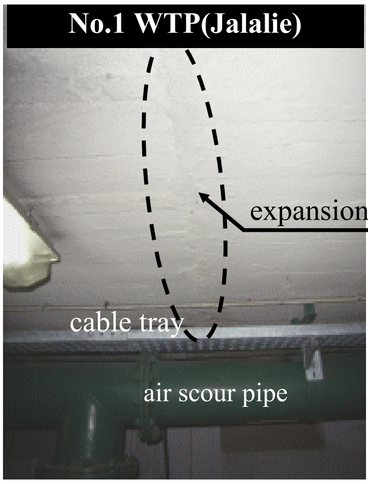


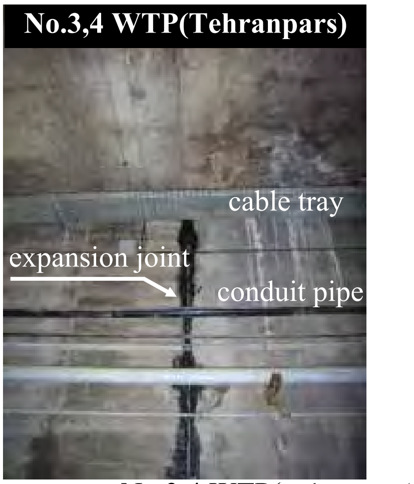
Sheet 9 Piping and Cabling Work around the Expansion Joint

The earthquake could generate displacement at expansion joint because the movements of structures are different from each other. That may cause damage to cables & pipes.

Summary of Existing Condition:

Flexible pipe is not installed around the expansion joint in most of WTPs. (except for No.5 WTP)
And it seems to be no expansion joints in Riservoirs or Pump Stations there.



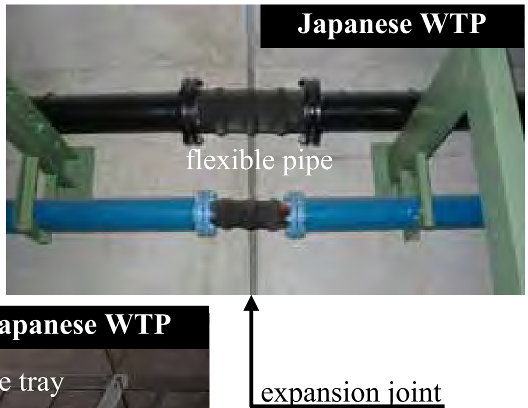


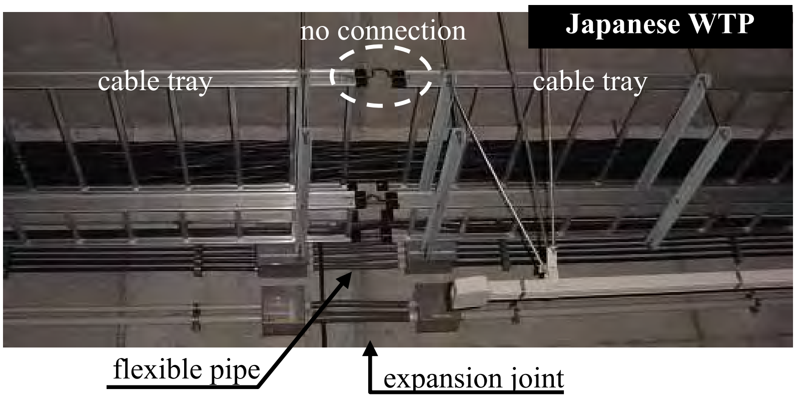
No.3,4 WTP(Tehranpars)

Typical Appearance

Proposed Countermeasure:

1) Installation of flexible pipe.
2) Devide a cable tray around the expansion joint.





Sheet 10 Spare Length of Cable

Enough spare length of cable is necessary to prevent damage to cable.

Summary of Existing Condition:

It seems there is not enough spare length of cable at most of the facilities. But except for corner portion, there is many slacks of cable. Therefore, the possibility of damage to the cable is considered as low.

Typical Appearance

Proposed Countermeasure:

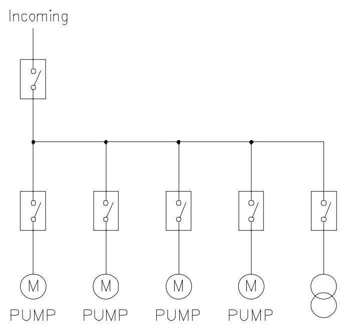
Rewiring of cable for the important equipment with enough spare length. (If necessary)

Sheet 11 Installation of Emergency Generator

Emergency generator is necessary for reservoirs with pumping station as well as WTP to ensure power source during power supply failure.

Summary of Existing Condition:

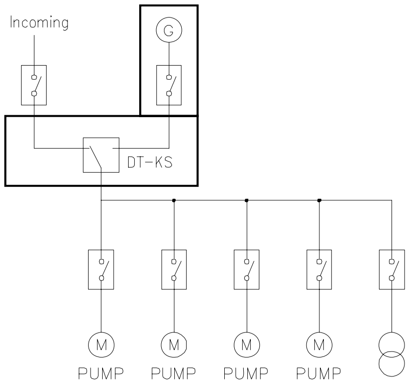
Emergency generator is installed at each WTP.
But there is no generator installed at reservoirs with pumping station.



Typical Single Line Diagram of Pumping Station

Proposed Countermeasure:

Installation of emergency generator at reservoirs with pumping station.



Typical Single Line Diagram of Pumping Station

Sheet 12 Construction of Anti-flowout Fence

Construction of anti-flowout fence under the oil tank is necessary to prevent secondary disaster.

Summary of Existing Condition:

There is no anti-flowout fence constructed under oil tank inside of the generator room.

Typical Appearance

Proposed Countermeasure:

1) Construction of anti-flowout fence.

Sheet 13 **Electric Post**

Electric post needs to be installed properly to prevent from toppling.

Summary of Existing Condition:

The electric post at No.22 Reservoir(Vanak) is leaning a little, in danger of toppling by earthquake. That may cause failure of facility.

No.22 Reservoir(Vanak)

No.22 Reservoir(Vanak)

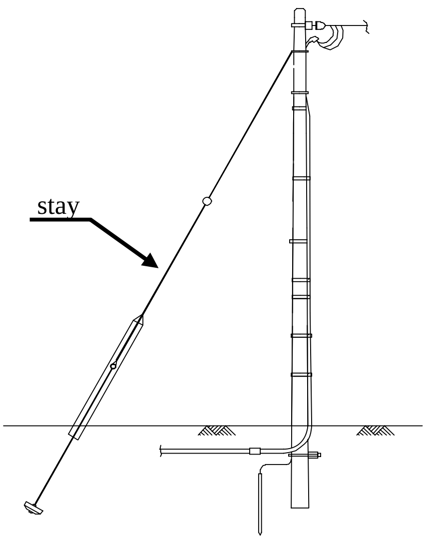
Typical Appearance

Proposed Countermeasure:

1) Installation of stay.

or

2) Underground wiring instead of overhead wiring.



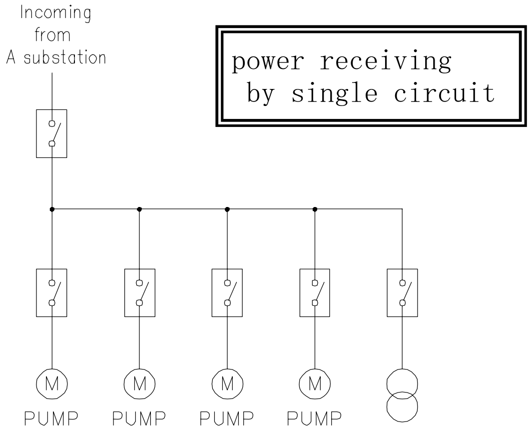
Japanese WTP

Sheet 14 Duplicate Incoming Cable

It is desirable to provide duplicate incoming cable for large scale and important facility.

Summary of Existing Condition:

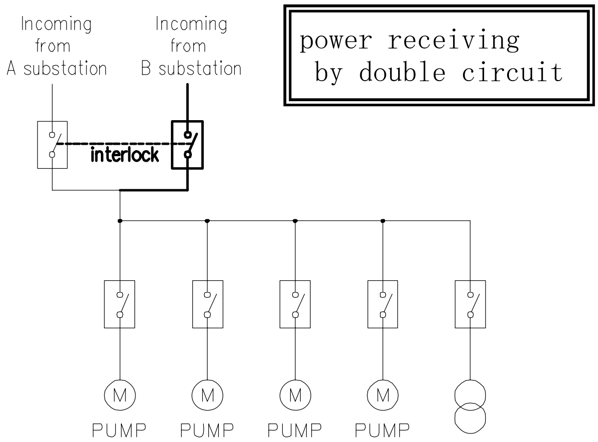
Almost all the facilities which is receiving power at 20kV are receiving double circuit.
But some large scale pumping stations, namely No.16(Soleymanieh), No.52(Esfahanak), No.68(Valiasr), No.114(Tarasht Pump Station) are receiving single line from electrical company.



Typical Single Line Diagram of Pumping Station

Proposed Countermeasure:

Duplicate incoming cable.



Typical Single Line Diagram of Pumping Station

Sheet 15 **Installation of Standby Pump**

Even though one of the pumps has damaged, standby pump can prevent failure of facility.

Summary of Existing Condition:

Standby pump is installed at all the pumping stations.

No Photo

Proposed Countermeasure:

No need to Install standby pump.

No Photo

Sheet 16 Installation of Flexible Pipe Between Fuel Tank and Generator

If flexible pipe is not installed, earthquake could damage the pipe and cause fuel leakage.

Summary of Existing Condition:

Flexible pipe between fuel tank and generator is not installed at all the WTP.

No.5 WTP(Lashkarak)

Typical Appearance

Proposed Countermeasure:

Installation of flexible pipe.

Japanese WTP

Appendix-6.2

Strength Calculation of the Foundation Bolt

Table of Contents

1. Purpose of calculation

Strength analysis of the foundation bolt should be carried out to confirm whether the equipment has stability against earthquake or not.

2. Method of calculation

The seismic force exerting on the equipment is divided into horizontal direction and vertical direction.

Each seismic force is calculated using following equations ;

Horizontal seismic force

FH = KH x W x 9.8 [N]

Vertical seismic force

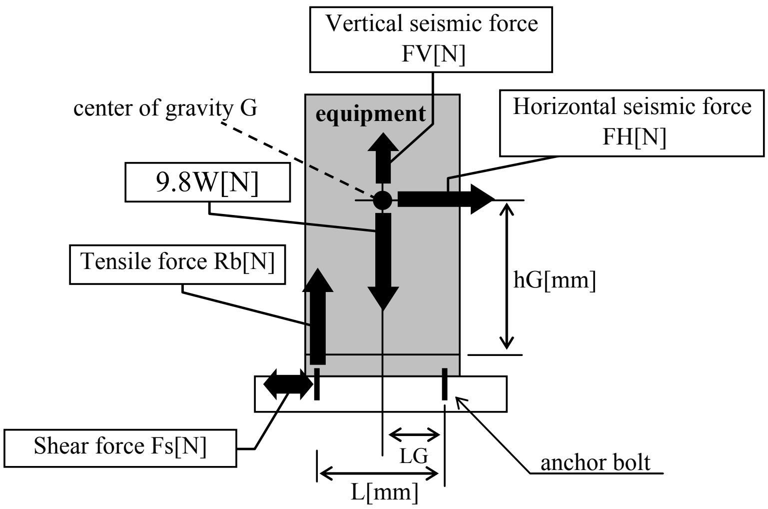
FV = (1/2) x FH [N]

Here, KH : horizontal seismic factor

If equipment is installed at basement or ground floor, KH=0.6

W : weight of equipment [kg]

In general, equipment is fixed with the structure using anchor bolts. When earthquake occurs, tensile force and shear force acts on the anchor bolts.
Following figure illustrates how the tensile force and the shear force work.



Here, hG[mm] : distance between installation level and center of gravity

LG[mm] : distance between anchor bolt and center of gravity

L[mm] : distance between anchor bolts

W[kg] : weight of equipment

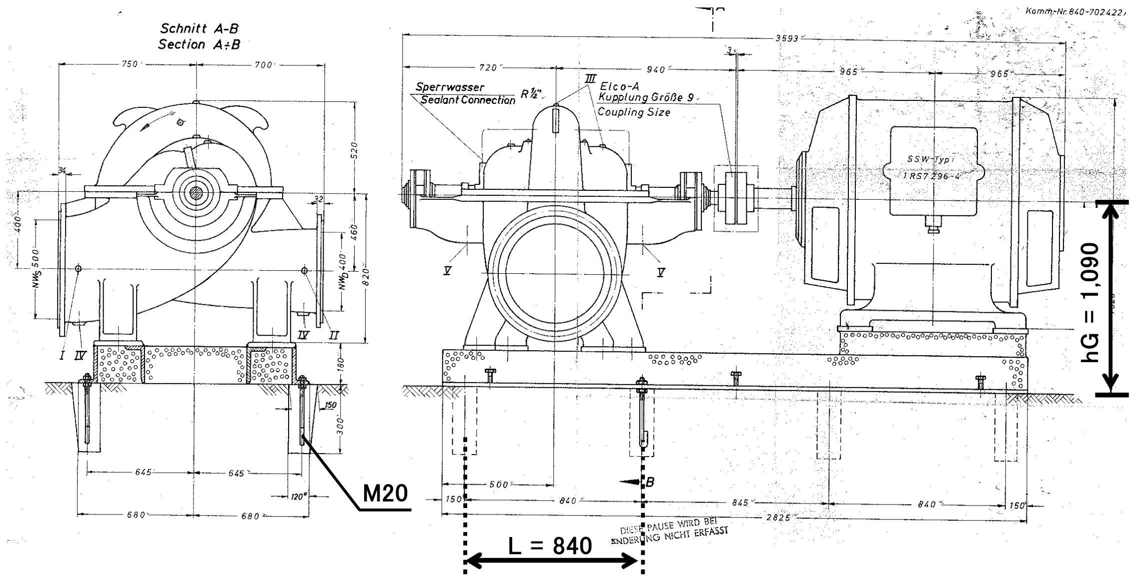
Following two equations must be satisfied to prevent the equipment from overturning or sideslipping by seismic force.

Allowable tensile force of anchor bolt > Tensile force on anchor bolt by seismic force
Allowable shear force of anchor bolt > Shear force on anchor bolt by seismic force

Appendix-6.2 Strength Calculation of the Foundation Bolt

No.1	Name of Facility	Name of Equipment	Installed Floor	Result of calculation
	No.25 Res	Pump	B1 Floor	**GOOD**

anchor bolt layout



condition of calculation

hG[mm]	LG[mm]	L[mm]	W[kg]	output P[W]	speed N[rpm]	allowance of amplitude a[m]	moment of rotation Mr[N-m]	weight while runnning FD[N]
1,090	645	840	2,500	290,000	1,500	0.000080	1,845	2,467

horizontal seismic factor KH	vertical seismic factor KV	shape of anchor bolt	thickness of concrete [mm]	fb[N]
0.6	0.3	type E	200	6,276

number of anchor bolts n	number of one side of the anchor bolts nt	diameter of anchor bolt d[mm]	area of anchor bolt A[cm2]	material
8	4	M20	3.14	SS400

allowable tensile stress of anchor bolt in short period ft[N/cm2]	allowable shear stress of anchor bolt in short period fs[N/cm2]	
17,652	13,239	

calculation

FH =KH x W x 9.8 = 14,700.0 [N]

FV =KV x W x 9.8 = 7,350.0 [N]

Mr = 97,400 x P / N x 9.8 = 1845 [N-m]

FD = (1/2) x a x (2πN / 60)^2 x W = 2467 [N]

1. Shear force on anchor bolt

$$Fs = \frac{FH+FD}{n \times A} \text{ [N/cm2]}$$

$$= \frac{17{,}167}{25.12} = \mathbf{683} \quad \textbf{[N/cm2]}$$

2. Tensile force on each anchor bolt

$$Rb = \frac{(FH+FD)xhG-(Wx9.8-FV-FD)xLG+Mr}{L \times nt} \text{ [N]}$$

$$= \frac{9{,}243{,}340}{3{,}360} = \mathbf{2{,}751} \quad \textbf{[N]}$$

3. Tensile stress on anchor bolt

$$Ft = \frac{Rb}{A} \text{ [N/cm2]}$$

$$= \frac{2{,}751}{3.14} = \mathbf{876} \quad \textbf{[N/cm2]}$$

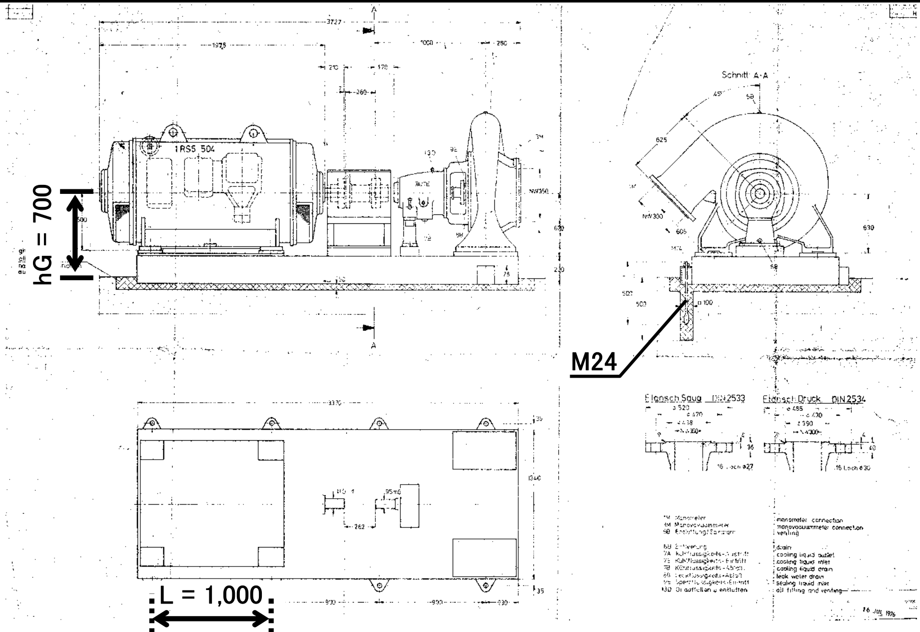
Result

Shear force on anchor bolt Fs			Allowable shear stress of anchor bolt in short period fs			
683	[N/cm2]	≦	**13,239**	[N/cm2]	====>	**GOOD**
Tensile stress on anchor bolt Ft			Allowable tensile stress of anchor bolt in short period ft			
876	[N/cm2]	≦	**17,652**	[N/cm2]	====>	**GOOD**
Tensile force on each anchor bolt Rb			Allowable tensile load of anchor bolt in short period fb			
2,751	[N]	≦	**6,276**	[N]	====>	**GOOD**

Appendix-6.2 Strength Calculation of the Foundation Bolt

No.2	Name of Facility	Name of Equipment	Installed Floor	Result of calculation
	No.56 Res	Pump	B1 Floor	**GOOD**

anchor bolt layout



condition of calculation

hG[mm]	LG[mm]	L[mm]	W[kg]	output P[W]	speed N[rpm]	allowance of amplitude a[m]	moment of rotation Mr[N-m]	weight while runnning FD[N]
700	700	1,000	5,000	710,000	1,500	0.000080	4,518	4,935

horizontal seismic factor KH	vertical seismic factor KV	shape of anchor bolt	thickness of concrete [mm]	fb[N]
0.6	0.3	type E	200	6,276

number of anchor bolts n	number of one side of the anchor bolts nt	diameter of anchor bolt d[mm]	area of anchor bolt A[cm2]	material
8	4	M24	3.14	SS400

allowable tensile stress of anchor bolt in short period ft[N/cm2]	allowable shear stress of anchor bolt in short period fs[N/cm2]	
17,652	13,239	

calculation

FH =KH x W x 9.8 = 29,400.0 [N]

FV =KV x W x 9.8 = 14,700.0 [N]

Mr = 97,400 x P / N x 9.8 = 4518 [N-m]

FD = (1/2) x a x (2πN / 60)^2 x W = 4935 [N]

1. Shear force on anchor bolt

$$Fs = \frac{FH+FD}{n \times A} \text{ [N/cm2]}$$

$$= \frac{34,335}{25.12} = \mathbf{1,367} \quad \textbf{[N/cm2]}$$

2. Tensile force on each anchor bolt

$$Rb = \frac{(FH+FD)xhG-(Wx9.8-FV-FD)xLG+Mr}{L \times nt} \text{ [N]}$$

$$= \frac{3,483,518}{4,000} = \mathbf{871} \quad \textbf{[N]}$$

3. Tensile stress on anchor bolt

$$Ft = \frac{Rb}{A} \text{ [N/cm2]}$$

$$= \frac{871}{3.14} = \mathbf{277} \quad \textbf{[N/cm2]}$$

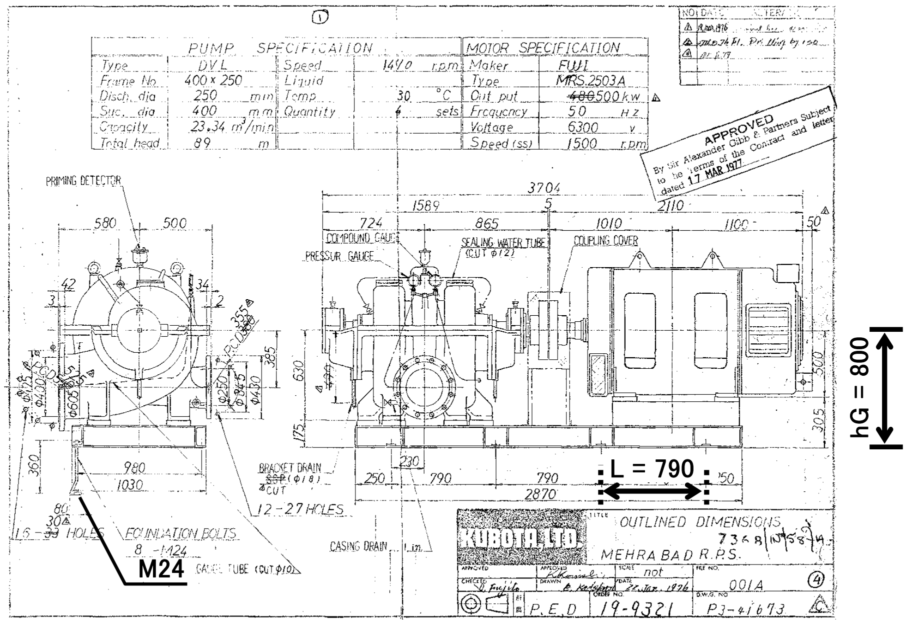
Result

Shear force on anchor bolt Fs			Allowable shear stress of anchor bolt in short period fs		
1,367	[N/cm2]	≦	**13,239**	[N/cm2]	====> **GOOD**
Tensile stress on anchor bolt Ft			Allowable tensile stress of anchor bolt in short period ft		
277	[N/cm2]	≦	**17,652**	[N/cm2]	====> **GOOD**
Tensile force on each anchor bolt Rb			Allowable tensile load of anchor bolt in short period fb		
871	[N]	≦	**6,276**	[N]	====> **GOOD**

Appendix-6.2 Strength Calculation of the Foundation Bolt

No.3	Name of Facility	Name of Equipment	Installed Floor	Result of calculation
	No.15 Res	Pump	B1 Floor	**GOOD**

anchor bolt layout



condition of calculation

hG[mm]	LG[mm]	L[mm]	W[kg]	output P[W]	speed N[rpm]	allowance of amplitude a[m]	moment of rotation Mr[N-m]	weight while runnning FD[N]
800	490	790	4,500	480,000	1,500	0.000080	3,054	4,441

horizontal seismic factor KH	vertical seismic factor KV	shape of anchor bolt	thickness of concrete [mm]	fb[N]
0.6	0.3	type E	200	6,276

number of anchor bolts n	number of one side of the anchor bolts nt	diameter of anchor bolt d[mm]	area of anchor bolt A[cm2]	material
8	4	M24	3.14	SS400

allowable tensile stress of anchor bolt in short period ft[N/cm2]	allowable shear stress of anchor bolt in short period fs[N/cm2]
17,652	13,239

calculation

FH =KH x W x 9.8 = 26,460.0 [N]

FV =KV x W x 9.8 = 13,230.0 [N]

Mr = 97,400 x P / N x 9.8 = 3054 [N-m]

FD = (1/2) x a x (2πN / 60)^2 x W = 4441 [N]

1. Shear force on anchor bolt

$$Fs = \frac{FH+FD}{n \times A} \ [N/cm2]$$

$$= \frac{30,901}{25.12} = \mathbf{1,230} \ \mathbf{[N/cm2]}$$

2. Tensile force on each anchor bolt

$$Rb = \frac{(FH+FD)xhG-(Wx9.8-FV-FD)xLG+Mr}{L \times nt} \ [N]$$

$$= \frac{11,773,644}{3,160} = \mathbf{3,726} \ \mathbf{[N]}$$

3. Tensile stress on anchor bolt

$$Ft = \frac{Rb}{A} \ [N/cm2]$$

$$= \frac{3,726}{3.14} = \mathbf{1,187} \ \mathbf{[N/cm2]}$$

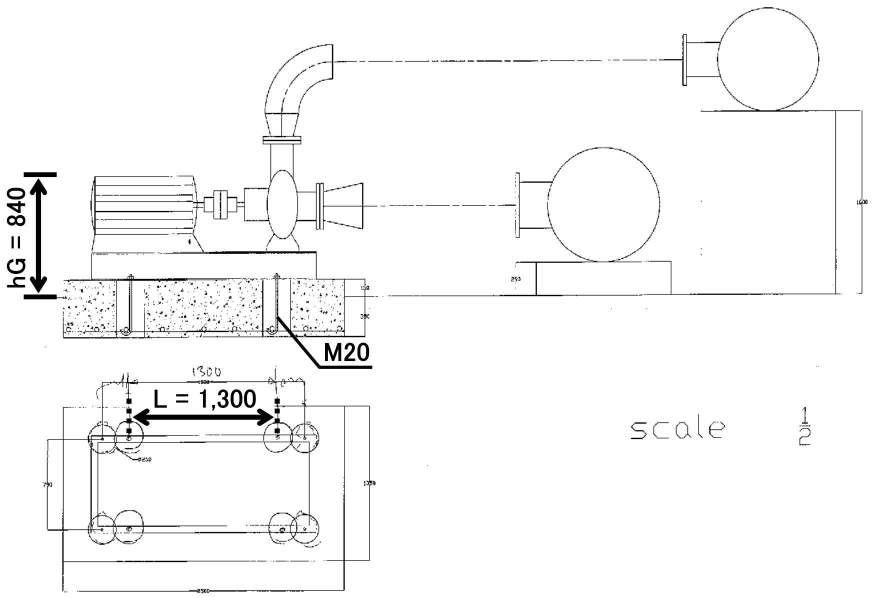
Result

Shear force on anchor bolt Fs			Allowable shear stress of anchor bolt in short period fs		
1,230 [N/cm2]	≦	**13,239** [N/cm2]	====>	**GOOD**	
Tensile stress on anchor bolt Ft			Allowable tensile stress of anchor bolt in short period ft		
1,187 [N/cm2]	≦	**17,652** [N/cm2]	====>	**GOOD**	
Tensile force on each anchor bolt Rb			Allowable tensile load of anchor bolt in short period fb		
3,726 [N]	≦	**6,276** [N]	====>	**GOOD**	

Appendix-6.2 Strength Calculation of the Foundation Bolt

No.4	Name of Facility	Name of Equipment	Installed Floor	Result of calculation
	No.81 Res	Pump	B1 Floor	**GOOD**

anchor bolt layout



condition of calculation

hG[mm]	LG[mm]	L[mm]	W[kg]	output P[W]	speed N[rpm]	allowance of amplitude a[m]	moment of rotation Mr[N-m]	weight while runnning FD[N]
840	395	1,300	2,000	250,000	1,500	0.000080	1,591	1,974

horizontal seismic factor KH	vertical seismic factor KV	shape of anchor bolt	thickness of concrete [mm]	fb[N]
0.6	0.3	type E	200	6,276

number of anchor bolts n	number of one side of the anchor bolts nt	diameter of anchor bolt d[mm]	area of anchor bolt A[cm2]	material
4	2	M20	3.14	SS400

allowable tensile stress of anchor bolt in short period ft[N/cm2]	allowable shear stress of anchor bolt in short period fs[N/cm2]
17,652	13,239

calculation

FH =KH x W x 9.8 = 11,760.0 [N]

FV =KV x W x 9.8 = 5,880.0 [N]

Mr = 97,400 x P / N x 9.8 = 1591 [N-m]

FD = (1/2) x a x (2πN / 60)^2 x W = 1974 [N]

1. Shear force on anchor bolt

$$Fs = \frac{FH+FD}{n \times A} \text{ [N/cm2]}$$

$$= \frac{13{,}734}{12.56} = \mathbf{1{,}093} \quad \textbf{[N/cm2]}$$

2. Tensile force on each anchor bolt

$$Rb = \frac{(FH+FD)xhG-(Wx9.8-FV-FD)xLG+Mr}{L \times nt} \text{ [N]}$$

$$= \frac{6{,}898{,}481}{2{,}600} = \mathbf{2{,}653} \quad \textbf{[N]}$$

3. Tensile stress on anchor bolt

$$Ft = \frac{Rb}{A} \text{ [N/cm2]}$$

$$= \frac{2{,}653}{3.14} = \mathbf{845} \quad \textbf{[N/cm2]}$$

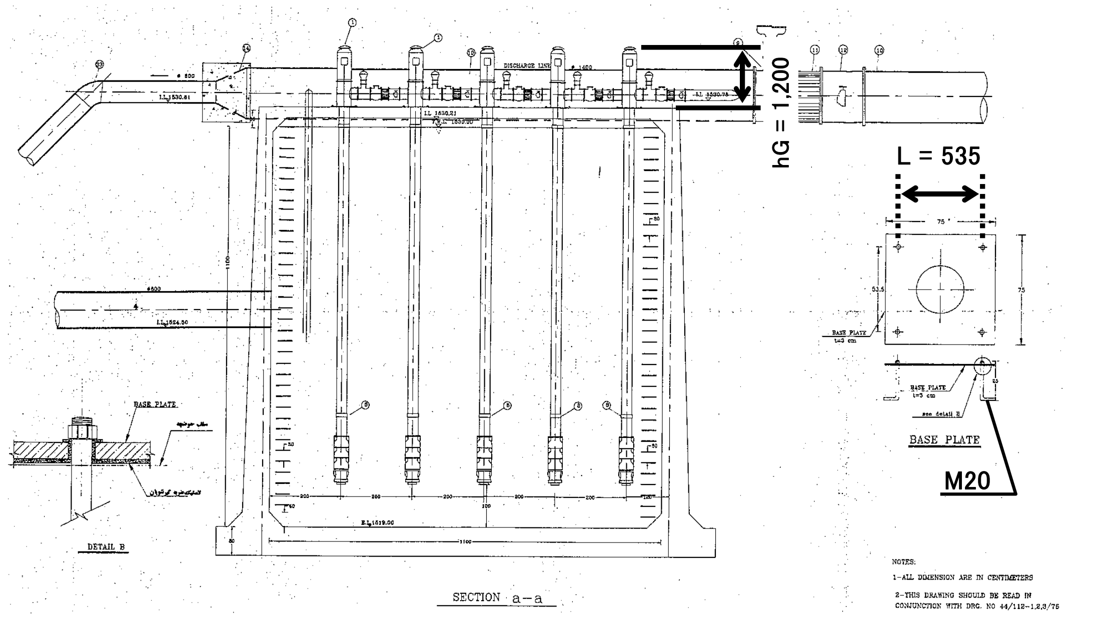
Result

Shear force on anchor bolt Fs			Allowable shear stress of anchor bolt in short period fs		
1,093 [N/cm2]	≦	**13,239** [N/cm2]	====>	**GOOD**	
Tensile stress on anchor bolt Ft			Allowable tensile stress of anchor bolt in short period ft		
845 [N/cm2]	≦	**17,652** [N/cm2]	====>	**GOOD**	
Tensile force on each anchor bolt Rb			Allowable tensile load of anchor bolt in short period fb		
2,653 [N]	≦	**6,276** [N]	====>	**GOOD**	

Appendix-6.2 Strength Calculation of the Foundation Bolt

No.5	Name of Facility	Name of Equipment	Installed Floor	Result of calculation
	No.37 Res	Pump	Ground Floor	**GOOD**

anchor bolt layout



condition of calculation

hG[mm]	LG[mm]	L[mm]	W[kg]	output P[W]	speed N[rpm]	allowance of amplitude a[m]	moment of rotation Mr[N-m]	weight while runnning FD[N]
1,200	268	535	1,300	200,000	1,500	0.000080	1,273	1,283

horizontal seismic factor KH	vertical seismic factor KV	shape of anchor bolt	thickness of concrete [mm]	fb[N]
0.6	0.3	type A (guess)	200	11,768
number of anchor bolts n	number of one side of the anchor bolts nt	diameter of anchor bolt d[mm]	area of anchor bolt A[cm2]	material
4	2	M20	3.14	SS400

allowable tensile stress of anchor bolt in short period ft[N/cm2]	allowable shear stress of anchor bolt in short period fs[N/cm2]	
17,652	13,239	

calculation

FH =KH x W x 9.8 = 7,644.0 [N]

FV =KV x W x 9.8 = 3,822.0 [N]

Mr = 97,400 x P / N x 9.8 = 1273 [N-m]

FD = (1/2) x a x (2πN / 60)^2 x W = 1283 [N]

1. Shear force on anchor bolt

$$Fs = \frac{FH+FD}{n \times A} \text{ [N/cm2]}$$

$$= \frac{8,927}{12.56} = \mathbf{711} \quad \textbf{[N/cm2]}$$

2. Tensile force on each anchor bolt

$$Rb = \frac{(FH+FD)xhG-(Wx9.8-FV-FD)xLG+Mr}{L \times nt} \text{ [N]}$$

$$= \frac{8,671,311}{1,070} = \mathbf{8,104} \quad \textbf{[N]}$$

3. Tensile stress on anchor bolt

$$Ft = \frac{Rb}{A} \text{ [N/cm2]}$$

$$= \frac{8,104}{3.14} = \mathbf{2,581} \quad \textbf{[N/cm2]}$$

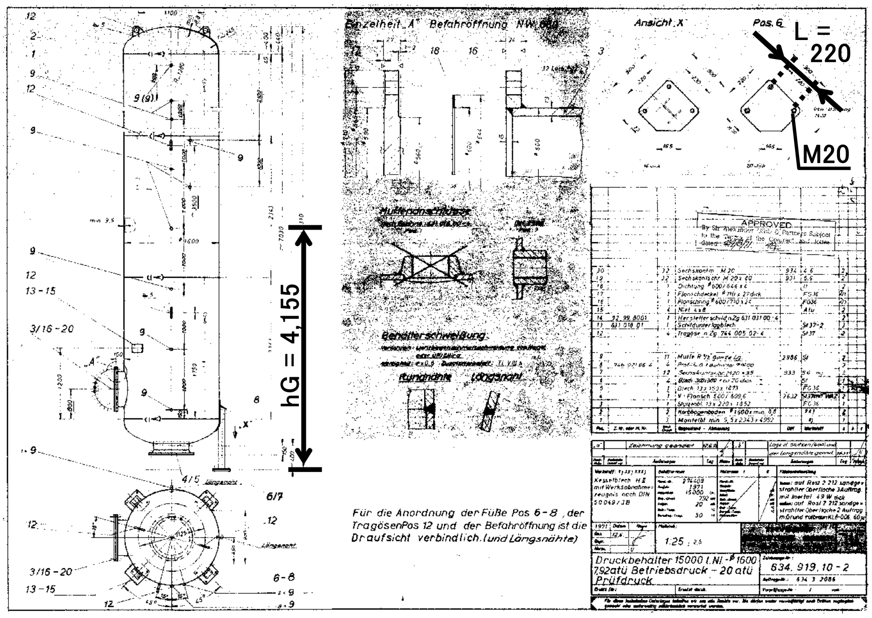
Result

Shear force on anchor bolt Fs			Allowable shear stress of anchor bolt in short period fs			
711	[N/cm2]	≦	**13,239**	[N/cm2]	====>	**GOOD**
Tensile stress on anchor bolt Ft			Allowable tensile stress of anchor bolt in short period ft			
2,581	[N/cm2]	≦	**17,652**	[N/cm2]	====>	**GOOD**
Tensile force on each anchor bolt Rb			Allowable tensile load of anchor bolt in short period fb			
8,104	[N]	≦	**11,768**	[N]	====>	**GOOD**

Appendix-6.2 Strength Calculation of the Foundation Bolt

No.6	Name of Facility	Name of Equipment	Installed Floor	Result of calculation
	No.2 Res	Surge Tank	B1 Floor	NO GOOD

anchor bolt layout



condition of calculation

hG[mm]	LG[mm]	L[mm]	W[kg]		
4,155	800	220	18,740		
horizontal seismic factor KH		vertical seismic factor KV	shape of anchor bolt	thickness of concrete [mm]	fb[N]
0.6		0.3	type C (guess)	180 (guess)	11,768
number of anchor bolts n		number of one side of the anchor bolts nt	diameter of anchor bolt d[mm]	area of anchor bolt A[cm2]	material
12		6	M20	3.14	SS400
allowable tensile stress of anchor bolt in short period ft[N/cm2]			allowable shear stress of anchor bolt in short period fs[N/cm2]		
17,652			13,239		

calculation

FH = KH x W x 9.8 = 110,191.2 [N]

FV = KV x W x 9.8 = 55,095.6 [N]

1. Shear force on anchor bolt

$$Fs = \frac{FH}{n \times A} \ [N/cm2]$$

$$= \frac{110,191}{37.68} = \mathbf{2,924} \quad \mathbf{[N/cm2]}$$

2. Tensile force on each anchor bolt

$$Rb = \frac{FH \times hG - (W \times 9.8 - FV) \times LG}{L \times nt} \ [N]$$

$$= \frac{354,999,316}{1,320} = \mathbf{268,939} \quad \mathbf{[N]}$$

3. Tensile stress on anchor bolt

$$Ft = \frac{Rb}{A} \ [N/cm2]$$

$$= \frac{268,939}{3.14} = \mathbf{85,649} \quad \mathbf{[N/cm2]}$$

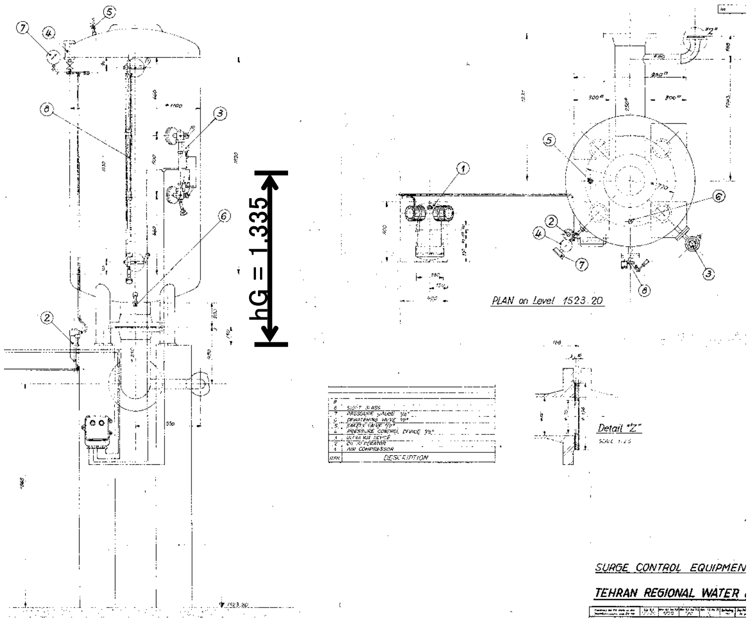
Result

Shear force on anchor bolt Fs			Allowable shear stress of anchor bolt in short period fs		
2,924 [N/cm2]	≦	**13,239** [N/cm2]	====>	**GOOD**
Tensile stress on anchor bolt Ft			Allowable tensile stress of anchor bolt in short period ft		
85,649 [N/cm2]	>	**17,652** [N/cm2]	====>	**NO GOOD**
Tensile force on each anchor bolt Rb			Allowable tensile load of anchor bolt in short period fb		
268,939 [N]	>	**11,768** [N]	====>	**NO GOOD**

Appendix-6.2 Strength Calculation of the Foundation Bolt

No.7	Name of Facility	Name of Equipment	Installed Floor	Result of calculation
	No.22 Res	Surge Tank (small)	B1 Floor	NO GOOD

anchor bolt layout



condition of calculation

hG[mm]	LG[mm]	L[mm]	W[kg]	
1,335	385	100	2,600 (guess)	
horizontal seismic factor KH	vertical seismic factor KV	shape of anchor bolt	thickness of concrete [mm]	fb[N]
0.6	0.3	type C (guess)	200	11,768
number of anchor bolts n	number of one side of the anchor bolts nt	diameter of anchor bolt d[mm]	area of anchor bolt A[cm2]	material
12	6	M24 (guess)	4.52	SS400
allowable tensile stress of anchor bolt in short period ft[N/cm2]		allowable shear stress of anchor bolt in short period fs[N/cm2]		
17,652		13,239		

calculation

FH =KH x W x 9.8 = 15,288.0 [N]

FV =KV x W x 9.8 = 7,644.0 [N]

1. Shear force on anchor bolt

$$Fs = \frac{FH}{n \times A} \quad [N/cm2]$$

$$= \frac{15,288}{54.24} = \mathbf{282} \quad \mathbf{[N/cm2]}$$

2. Tensile force on each anchor bolt

$$Rb = \frac{FHxhG-(Wx9.8-FV)xLG}{L \times nt} \quad [N]$$

$$= \frac{13,542,620}{600} = \mathbf{22,571} \quad \mathbf{[N]}$$

3. Tensile stress on anchor bolt

$$Ft = \frac{Rb}{A} \quad [N/cm2]$$

$$= \frac{22,571}{4.52} = \mathbf{4,994} \quad \mathbf{[N/cm2]}$$

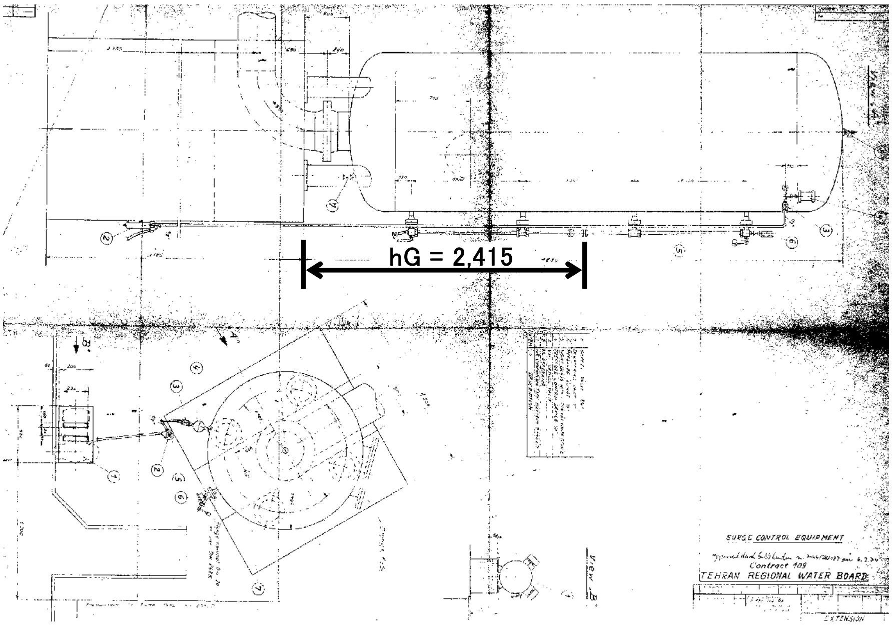
Result

Shear force on anchor bolt Fs			Allowable shear stress of anchor bolt in short period fs			
282	[N/cm2]	≦	**13,239**	[N/cm2]	====>	**GOOD**
Tensile stress on anchor bolt Ft			Allowable tensile stress of anchor bolt in short period ft			
4,994	[N/cm2]	≦	**17,652**	[N/cm2]	====>	**GOOD**
Tensile force on each anchor bolt Rb			Allowable tensile load of anchor bolt in short period fb			
22,571	[N]	>	**11,768**	[N]	====>	NO GOOD

Appendix-6.2 Strength Calculation of the Foundation Bolt

No.8	Name of Facility	Name of Equipment	Installed Floor	Result of calculation
	No.22 Res	Surge Tank (big)	B1 Floor	NO GOOD

anchor bolt layout



condition of calculation

hG[mm]	LG[mm]	L[mm]	W[kg]	
2,415	550	150	7,200 (guess)	

horizontal seismic factor KH	vertical seismic factor KV	shape of anchor bolt	thickness of concrete [mm]	fb[N]
0.6	0.3	type C (guess)	200	11,768
number of anchor bolts n	number of one side of the anchor bolts nt	diameter of anchor bolt d[mm]	area of anchor bolt A[cm2]	material
12	6	M24 (guess)	4.52	SS400

allowable tensile stress of anchor bolt in short period ft[N/cm2]	allowable shear stress of anchor bolt in short period fs[N/cm2]	
17,652	13,239	

calculation

FH = KH x W x 9.8 = 42,336.0 [N]

FV = KV x W x 9.8 = 21,168.0 [N]

1. Shear force on anchor bolt

$$Fs = \frac{FH}{n \times A} \ [N/cm2]$$

$$= \frac{42,336}{54.24} = \mathbf{781} \ \mathbf{[N/cm2]}$$

2. Tensile force on each anchor bolt

$$Rb = \frac{FHxhG-(Wx9.8-FV)xLG}{L \times nt} \ [N]$$

$$= \frac{75,075,840}{900} = \mathbf{83,418} \ \mathbf{[N]}$$

3. Tensile stress on anchor bolt

$$Ft = \frac{Rb}{A} \ [N/cm2]$$

$$= \frac{83,418}{4.52} = \mathbf{18,455} \ \mathbf{[N/cm2]}$$

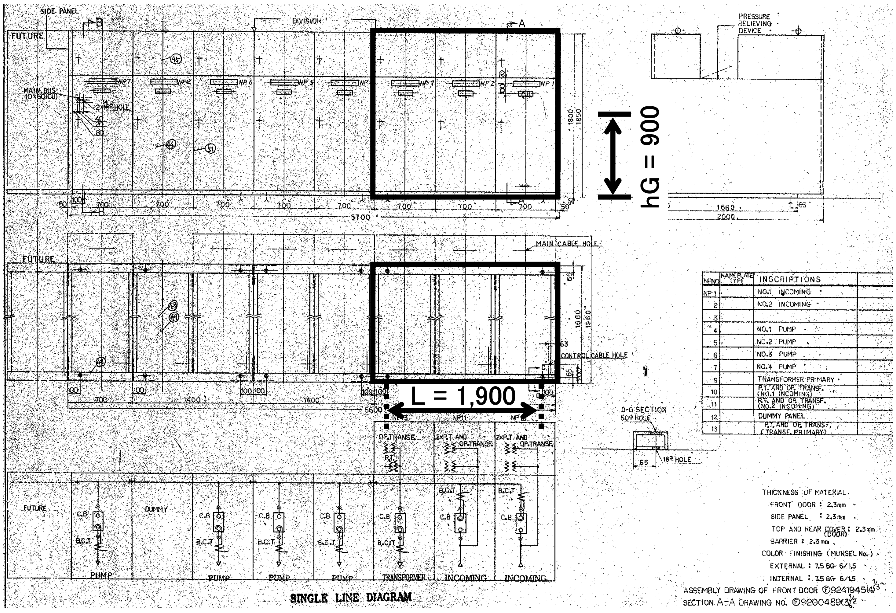
Result

Result						
Shear force on anchor bolt Fs			Allowable shear stress of anchor bolt in short period fs			
781	[N/cm2]	≦	**13,239**	[N/cm2]	====>	**GOOD**
Tensile stress on anchor bolt Ft			Allowable tensile stress of anchor bolt in short period ft			
18,455	[N/cm2]	>	**17,652**	[N/cm2]	====>	**NO GOOD**
Tensile force on each anchor bolt Rb			Allowable tensile load of anchor bolt in short period fb			
83,418	[N]	>	**11,768**	[N]	====>	**NO GOOD**

Appendix-6.2 Strength Calculation of the Foundation Bolt

No.9	Name of Facility	Name of Equipment	Installed Floor	Result of calculation
	No.15 Res	High Tension Cubicle	Ground Floor	**GOOD**

anchor bolt layout



condition of calculation

hG[mm]	LG[mm]	L[mm]	W[kg]		
900	950	1,900	3,000		

horizontal seismic factor KH	vertical seismic factor KV	shape of anchor bolt	thickness of concrete [mm]	fb[N]
0.6	0.3	type E	180	5,492
number of anchor bolts n	number of one side of the anchor bolts nt	diameter of anchor bolt d[mm]	area of anchor bolt A[cm2]	material
4	2	M16	2.01	SS400

allowable tensile stress of anchor bolt in short period ft[N/cm2]	allowable shear stress of anchor bolt in short period fs[N/cm2]
17,652	13,239

calculation

FH =KH x W x 9.8 = 17,640.0 [N]

FV =KV x W x 9.8 = 8,820.0 [N]

1. Shear force on anchor bolt

$$Fs = \frac{FH}{n \times A} \text{ [N/cm2]}$$

$$= \frac{17,640}{8.04} = \mathbf{2,194} \text{ [N/cm2]}$$

2. Tensile force on each anchor bolt

$$Rb = \frac{FH \times hG-(W \times 9.8-FV) \times LG}{L \times nt} \text{ [N]}$$

$$= \frac{-3,675,000}{3,800} = \mathbf{-967} \text{ [N]}$$

3. Tensile stress on anchor bolt

$$Ft = \frac{Rb}{A} \text{ [N/cm2]}$$

$$= \frac{-967}{2.01} = \mathbf{-481} \text{ [N/cm2]}$$

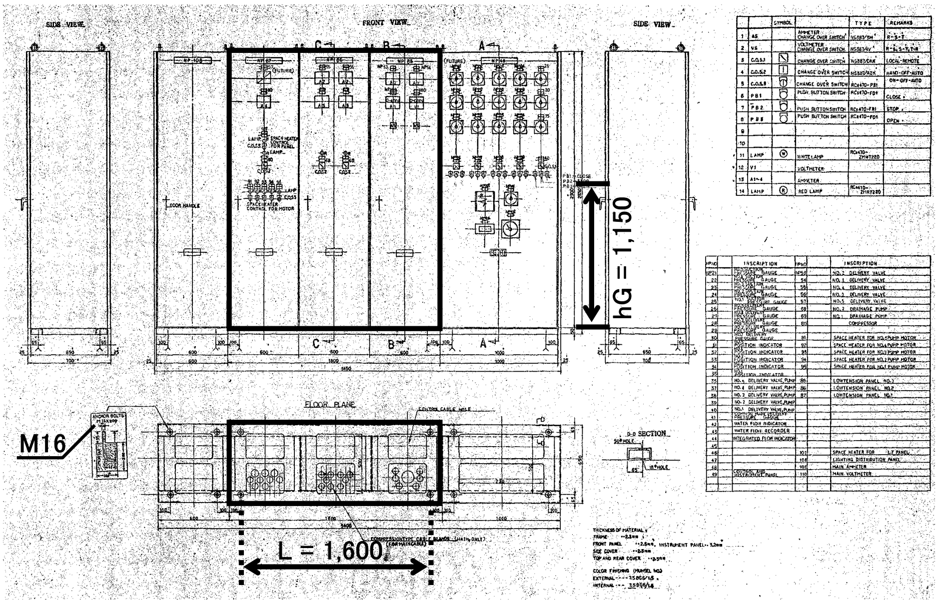
Result

Shear force on anchor bolt Fs			Allowable shear stress of anchor bolt in short period fs		
2,194	[N/cm2]	≦	**13,239**	[N/cm2]	====> **GOOD**
Tensile stress on anchor bolt Ft			Allowable tensile stress of anchor bolt in short period ft		
-481	[N/cm2]	≦	**17,652**	[N/cm2]	====> **GOOD**
Tensile force on each anchor bolt Rb			Allowable tensile load of anchor bolt in short period fb		
-967	[N]	≦	**5,492**	[N]	====> **GOOD**

Appendix-6.2 Strength Calculation of the Foundation Bolt

No.10	Name of Facility	Name of Equipment	Installed Floor	Result of calculation
	No.15 Res	Low Tension Cubicle	Ground Floor	**GOOD**

anchor bolt layout



condition of calculation

hG[mm]	LG[mm]	L[mm]	W[kg]		
1,150	800	1,600	1,500		

horizontal seismic factor KH	vertical seismic factor KV	shape of anchor bolt	thickness of concrete [mm]	fb[N]
0.6	0.3	type E	180	5,492
number of anchor bolts n	number of one side of the anchor bolts nt	diameter of anchor bolt d[mm]	area of anchor bolt A[cm2]	material
4	2	M16	2.01	SS400

allowable tensile stress of anchor bolt in short period ft[N/cm2]	allowable shear stress of anchor bolt in short period fs[N/cm2]	
17,652	13,239	

calculation

FH =KH x W x 9.8 = 8,820.0 [N]

FV =KV x W x 9.8 = 4,410.0 [N]

1. Shear force on anchor bolt

$$Fs = \frac{FH}{n \times A} \text{ [N/cm2]}$$

$$= \frac{8,820}{8.04} = \mathbf{1,097} \quad \textbf{[N/cm2]}$$

2. Tensile force on each anchor bolt

$$Rb = \frac{FHxhG-(Wx9.8-FV)xLG}{L \times nt} \text{ [N]}$$

$$= \frac{1,911,000}{3,200} = \mathbf{597} \quad \textbf{[N]}$$

3. Tensile stress on anchor bolt

$$Ft = \frac{Rb}{A} \text{ [N/cm2]}$$

$$= \frac{597}{2.01} = \mathbf{297} \quad \textbf{[N/cm2]}$$

Result

Shear force on anchor bolt Fs			Allowable shear stress of anchor bolt in short period fs			
1,097	[N/cm2]	≦	**13,239**	[N/cm2]	====>	**GOOD**
Tensile stress on anchor bolt Ft			Allowable tensile stress of anchor bolt in short period ft			
297	[N/cm2]	≦	**17,652**	[N/cm2]	====>	**GOOD**
Tensile force on each anchor bolt Rb			Allowable tensile load of anchor bolt in short period fb			
597	[N]	≦	**5,492**	[N]	====>	**GOOD**

Appendix-6.2 Strength Calculation of the Foundation Bolt

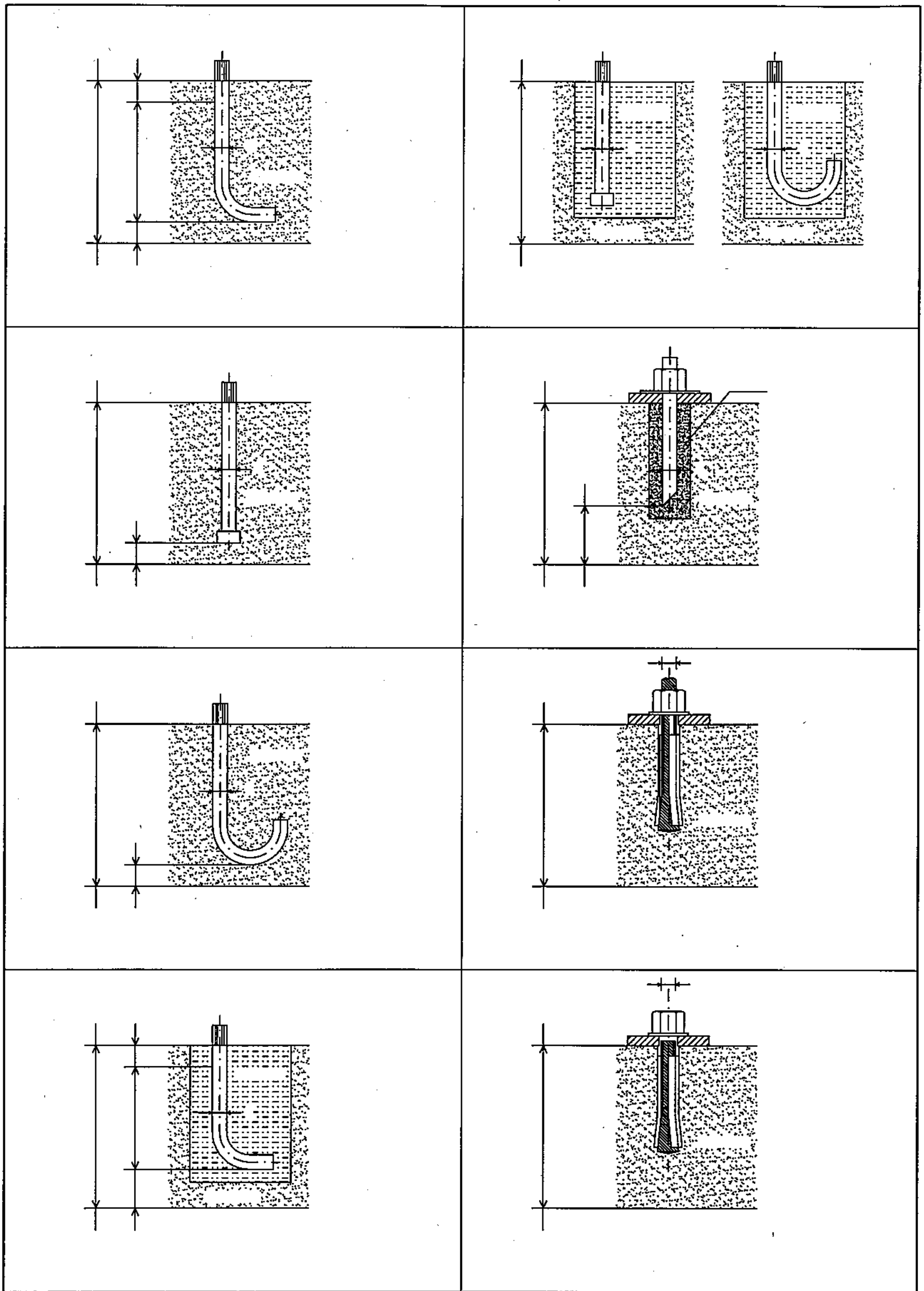
Table 1. Allowable stress of anchor bolt [N/cm2]

material	diameter of anchor bolt	in long period		in short period	
		Tensile(ft)	Shear(fs)	Tensile(ft)	Shear(fs)
SS400	under 40[mm]	11,768	8,826	17,652	13,239
	over 40[mm]	10,787	8,041	16,181	12,062
SUS304	under 40[mm]	10,003	7,502	15,004	11,258
	over 40[mm]	9,169	6,835	13,759	10,258

Table 2. Allowable tensile load of anchor bolt in short period (fb[N])

shape of anchor bolt (see next page)	diameter of anchor bolt d[mm]	thickness of concrete [mm]			
		120	150	180	200
TypeA	M8	3,138	4,315	5,590	6,374
	M10	3,923	5,394	6,963	7,943
	M12	4,707	6,570	8,336	9,512
	M16	-	8,728	11,180	11,768
	M20	-	-	11,768	11,768
	M24	-	-	-	11,768
TypeB	M8	8,826	8,826	8,826	8,826
	M10	11,768	11,768	11,768	11,768
	M12	11,768	11,768	11,768	11,768
	M16	-	11,768	11,768	11,768
	M20	-	-	11,768	11,768
	M24	-	-	-	11,768
TypeC	M8	8,826	8,826	8,826	8,826
	M10	11,768	11,768	11,768	11,768
	M12	11,768	11,768	11,768	11,768
	M16	-	11,768	11,768	11,768
	M20	-	-	11,768	11,768
	M24	-	-	-	11,768
TypeD	M8	1,569	2,354	3,138	3,727
	M10	1,961	2,942	3,923	4,609
	M12	-	3,530	4,707	5,590
	M16	-	-	5,492	6,276
	M20	-	-	5,492	6,276
	M24	-	-	-	6,276

shape of anchor bolt (see next page)	diameter of anchor bolt d[mm]	thickness of concrete [mm]			
		120	150	180	200
TypeE	M8	3,138	4,511	5,492	6,276
	M10	3,138	4,511	5,492	6,276
	M12	-	4,511	5,492	6,276
	M16	-	-	5,492	6,276
	M20	-	-	5,492	6,276
	M24	-	-	-	-
TypeF					
	M10	7,453	7,453	7,453	7,453
	M12	9,022	9,022	9,022	9,022
	M16	-	11,768	11,768	11,768
	M20	-	-	11,768	11,768
TypeG	M8	2,942	2,942	2,942	2,942
	M10	3,727	3,727	3,727	3,727
	M12	6,570	6,570	6,570	6,570
	M16	9,022	9,022	9,022	9,022
	M20	11,768	11,768	11,768	11,768
	M24	11,768	11,768	11,768	11,768
TypeH	M8	735	735	735	735
	M10	735	735	735	735
	M12	735	735	735	735
	M16	1,177	1,177	1,177	1,177
	M20	1,177	1,177	1,177	1,177
	M24	1,177	1,177	1,177	1,177



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The Study on Water Supply System Resistant to Earthquakes in Tehran Municipality in the Islamic Republic of Iran

TYPE OF ANCHOR BOLT

Fig. 1

Appendix-6.3

Countermeasures on Equipment

Table of Contents

Equipment List(1/3)

No.	Name of Facilities	Location	Existing / Future	Main Information of Existing Equipment: Specification of Pump – Nominal Q[m3/h] x P[kW] x	Num. total	Num. duty	Num. standby	Pump Manufacturer	Motor Manufacturer	receiving voltage [V] 1 : 20 [kV] 2 : 400 [V]	number of incoming cable	number of trans-former	capacity of transformer [kVA]
Reservoir													
No.1	Distribution Reservoir	Yousefabad	Existing	1,600m3/h x 950kW x 1,000m3/h x 590kW x 900m3/h x 205kW x 1,360m3/h x 800kW x 1,360m3/h x 750kW x	2 1 2 2 1	1 1 1 1	4	KSB KSB HARLAND KSB KSB	SIEMENS SIEMENS SIEMENS SIEMENS SIEMENS	1	2	3	2*3500 +1*500
No.2	Distribution Reservoir	Bisim	Existing	1,300m3/h x 300kW x 1,370m3/h x 380kW x	2 2	1 1	2	HARLAND KSB	SIEMENS SIEMENS	1	2	3	3*1000
No.3	Distribution Reservoir	Amirabad	Existing	no pump									
No.4	Distribution Reservoir	Behjatabad	Existing	no pump									
No.5	Distribution Reservoir	Bahar	Existing	no pump									
No.6	Distribution Reservoir	Eshratabad	Existing	no pump									
No.7	Distribution Reservoir	Resalat - Majidieh	Existing	no pump									
No.8	Distribution Reservoir	Upper Amirabad	Existing	330m3/h x 220kW x 500m3/h x 220kW x	1 2	1 1	1	KOUSAR KOUSAR	PARKINSON PARKINSON	2	1		
No.9	Distribution Reservoir	Lower Yousefabad	Existing	no pump									
No.10	Distribution Reservoir	Abbasabad	Existing	no pump									
No.11	Distribution Reservoir	Narmak	Existing	no pump									
No.12	Distribution Reservoir	Sepah Bank	Existing	300m3/h x 110kW x	3	2	1	HARLAND	SIEMENS	2	1		
No.13	Distribution Reservoir	Karaj Road	Existing	800m3/h x 330kW x 500m3/h x 220kW x	6 6	5 5	2	KOUSAR KOUSAR	US MOTOR NEWMAN	1	2	6	1*1000 +5*500
No.14	Distribution Reservoir	Upper Yousefabad	Existing	840m3/h x 300kW x 1,600m3/h x 560kW x	3 3	2 2	1 1	KSB KSB	SIEMENS SIEMENS	1	2	4	2*1000 +800+630
No.15	Distribution Reservoir	Mehrabad	Existing	1,400m3/h x 480kW x	4	3	1	KUBOTA	FUJI	1	2	5	2*2000+2*800+250
No.16	Distribution Reservoir	Soleymanieh	Existing	1,800m3/h x 700kW x	4	2	2	KUBOTA	FUJI	1	1	4	3*1600+630
No.17	Booster Station	Chizar Booster	Existing	6,000m3/h x 1,000kW x 4,200m3/h x 540kW x	2 2	1 1	2	KSB KSB	SIEMENS SIEMENS	1	2	2	2*2000
No.18	Distribution Reservoir	Gisha	removed										
No.19	Distribution Reservoir	Mobarakabad	Existing	1,800m3/h x 730kW x	3	2	1	KSB	SIEMENS	1	2	3	3*1600
No.20	Distribution Reservoir	Lower Hesarak	Existing	800m3/h x 270kW x	4	3	1	KSB	SIEMENS	1	2	2	2*800
No.21	Distribution Reservoir	Chizar	Existing	1,900m3/h x 1,050kW x 1,500m3/h x 800kW x	4 3	3 2	2	KSB KSB	SIEMENS SIEMENS	1	2	3	2*3000 +2500
No.22	Distribution Reservoir	Vanak	Existing	420m3/h x 250kW x 500m3/h x 340kW x 700m3/h x 480kW x	3 3 2	2 2 2	2	KSB KSB KSB	SIEMENS SIEMENS SIEMENS	1	2	4	2*2000 +2*1000
No.23	Distribution Reservoir	Niavaran	Existing	no pump									
No.24	Distribution Reservoir	Mahmoudieh	Existing	300m3/h x 200kW x 600m3/h x 400kW x	2 2	 1	3	KSB KSB	SIEMENS SIEMENS	1	2	3	2*315 +200
No.25	Distribution Reservoir	Lower Manzarieh	Existing	900m3/h x 290kW x	3	2	1	KSB	SIEMENS	1	2	3	3*400
No.26	Distribution Reservoir	Upper Hesarak	Existing	400m3/h x 132kW x	2	1	1	KSB	SIEMENS	1	2	2	2*160
No.27	Distribution Reservoir	Upper Manzarieh	Existing	300m3/h x 132kW x	3	2	1	KSB	SIEMENS	2	1		
No.28	Distribution Reservoir	Darband	Existing	200m3/h x 110kW x 100m3/h x 11.2kW x	2 1	1 1	1	HARLAND KSB	NEWMAN SEVER	2	1		
No.29	Distribution Reservoir	Azargah	Existing	no pump									
No.30	Distribution Reservoir	Velenjak	Existing	no pump									
No.31	Distribution Reservoir	Tehran now	Existing	no pump									
No.32	Distribution Reservoir	Aliabad + Ext.	Existing	350m3/h x 150kW x 350m3/h x 150kW x	3 2	1 1	3	KOUSAR KOUSAR	NEWMAN NEWMAN	2	1		
No.33	Distribution Reservoir	Upper Darband	Existing	no pump									
No.34	Distribution Reservoir	Shahran	Existing	150m3/h x 115kW x 200m3/h x 150kW x	2 1	1 1	1	KOUSAR KOUSAR	NEWMAN NEWMAN	2	1		
No.35	Distribution Reservoir	Shahrake Ghods	Cancelled										
No.36	Distribution Reservoir	Moshirieh	Existing	300m3/h x 220kW x	6	5	1	H.X.B&B.P.N	NEWMAN	2	1		
No.37	Distribution Reservoir	Lower Farahzad	Existing	500m3/h x 200kW x 750m3/h x 260kW x	2 5	1 4	2	KOUSAR KOUSAR	NEWMAN NEWMAN	2	1		
No.38	Distribution Reservoir	Evin + Ext.	Existing	500m3/h x 220kW x	4	2	2	KOUSAR	NEWMAN	2	1		
No.39	Distribution Reservoir	Zargandeh	Not used	no pump									
No.40	Distribution Reservoir	Pasdaran	Existing	670m3/h x 191kW x	4	2	2	KSB	SIEMENS	1	2	4	3*500+800
No.41	Distribution Reservoir	Saheb Qaranieh	Existing	no pump									
No.42	Distribution Reservoir	Hosseinabad	Not used	no pump									
No.43	Distribution Reservoir	Tehran Pars	Existing	500m3/h x 220kW x	4	2	2	KOUSAR	NEWMAN	2	1		

Countermeasures on Equipment (A = Needs Countermeasure, B = Partly Needs Countermeasure, C = Already Countermeasured)

No.	(1) No.1 Surge Tank	(1) No.2 Trans-former	(1) No.3 Battery	(1) No.4 UPS	(1) No.5 Electrical Panel High Tension	(1) No.5 Electrical Panel Low Tension	(1) No.6 Flexible Pipe Exp. J	(1) No.6 Flexible Pipe Fuel	(1) No.7 Electric Post	(1) No.8 Chlorine Cylinder	(2) No.9 Anti-flowout Fence	(2) No.10 Emergency Generator	(2) No.10 Capacity [kVA]	(2) No.11 Duplicate Incoming Cable	(2) No.12 Chlorine Dosing Equipment
Reservoir															
No.1		A	B		C							A	2308 x 2	C	
No.2	A	A	A		C							A	2308 x 1	C	
No.3															
No.4															
No.5															
No.6															
No.7															
No.8						A						A	667 x 1		
No.9															
No.10															
No.11															
No.12						A						A	638 x 1		
No.13		A	A		C	A						A	2308 x 2	C	
No.14		A	A		C							A	2308 x 2	C	
No.15		A	A		C							A	2308 x 2	C	
No.16		A	A		C							A	2308 x 1	A	
No.17		A	A		C							A	2308 x 1	C	
No.18															
No.19		A	A		C							A	2308 x 1	C	
No.20		A	A		C							A	2308 x 1	C	
No.21		A	A		C							A	2308 x 3	C	
No.22	A	A	A		C				A			A	2308 x 2	C	
No.23															
No.24		A	A		C							A	638 x 1	C	
No.25		A	A		C							A	897 x 1	C	
No.26		A	A		C							A	450 x 1	C	
No.27						A						A	450 x 1		
No.28						A						A	211 x 1		
No.29															
No.30															
No.31															
No.32						A						A	450 x 1		
No.33															
No.34						A						A	450 x 1		
No.35															
No.36						A						A	2308 x 1		
No.37						A						A	2308 x 1		
No.38						A						A	667 x 1		
No.39															
No.40		A	A		C							A	638 x 1	C	
No.41															
No.42															
No.43						A						A	667 x 1		

Equipment List(2/3)

No.	Name of Facilities	Location	Existing / Future	Main Information of Existing Equipment													Countermeasures on Equipment (A = Needs Countermeasure, B = Partly Needs Countermeasure, C = Already Countermeasured)														
				Specification of Pump							Pump Manufacturer	Motor Manufacturer	receiving voltage [V]	number of incoming cable	number of trans-former	capacity of transformer [kVA]	(1) Measures for Minimization of Damage Occurrence										(2) Measures for Minimization of Damage Effec				
				Nominal Q[m3/h]	x	P[kW]	x	Num.					1 : 20 [kV] 2 : 400 [V]				No.1	No.2	No.3	No.4	No.5		No.6		No.7	No.8	No.9	No.10		No.11	No.12
								total	duty	standby							Surge Tank	Trans-former	Battery	UPS	Electrical Panel		Flexible Pipe		Electric Post	Chlorine Cylinder	Anti-flowout Fence	Emergency Generator	Capacity [kVA]	Duplicate Incoming Cable	Chlorine Dosing Equipment
																					High Tension	Low Tension	Exp. J	Fuel							
No.44	Break Pressure Tank	Majidieh Pressure Reducer	Not used	no pump																											
No.45	Distribution Reservoir	Lavizan	Future																												
No.46	Distribution Reservoir	Lower Lashgarak	Future																												
No.47	Distribution Reservoir	Television Hill	For green area	no pump																											
No.48	Distribution Reservoir	Imam Hossein	Future																												
No.49	Distribution Reservoir	Imam Hossein	Future																												
No.50	Distribution Reservoir	Imam Hossein	Future																												
No.51	Distribution Reservoir	Qasr-e-Firouzeh	Existing	no pump																											
No.52	Contact Tank	Esfahanak	Existing	2,200m3/h	x	150kW	x	4	3	1	KSB	SIEMENS	1	1	3	2*500+1000		A	A		C							A	667 x 1	A	
No.53	Distribution Reservoir	Soleymanieh No.2	Existing	no pump																											
No.54	Distribution Reservoir	Aria Shahr	Not used																												
No.55	Distribution Reservoir	Bagh Feiz	Existing	no pump																											
No.56	Distribution Reservoir	Kan	Existing	2,975m3/h 1,250m3/h	x x	710kW 690kW	x x	5 5	4 4	1 1	KSB KUBOTA	SIEMENS FUJI	1	2	5	3*2500 +750+250		A	A		C							A	2308 x 4	C	
No.57	Distribution Reservoir	Jannatabad + Ext.	Existing	2,875m3/h	x	930kW	x	5	4	1	KUBOTA	FUJI	1	2	4	3*3000+250		A	A		C							A	2308 x 3	C	
No.58	Distribution Reservoir	Lower Pounak + Ext.	Existing	2,825m3/h 2,825m3/h	x x	830kW 860kW	x x	4 1	3 1	1	KUBOTA KUBOTA	FUJI FUJI	1	2	3	2*2500+250		A	A		C							A	2308 x 3	C	
No.59	Distribution Reservoir	North Kan	Existing	800m3/h 500m3/h	x x	330kW 220kW	x x	3 2	2 2	1	KOUSAR KOUSAR	1*US MOTOR, 2*GE NEWMAN	2	1								A						A	2308 x 1		
No.60	Distribution Reservoir	Molla Sadra	Future																												
No.61	Distribution Reservoir	Northern Amirabad	Existing	no pump																											
No.62	Break Pressure Tank	Kazemabad	Not used	no pump																											
No.63	Distribution Reservoir	Upper Massoudieh	Existing	no pump																											
No.64	Distribution Reservoir	Afsarieh Reservoir	Not used	no pump																											
No.65	Distribution Reservoir	Khaniabad	Existing	810m3/h	x	220kW	x	4	3	1	KOUSAR	NEWMAN	1	2	1	1250		A	A		C	A						A	2308 x 1	C	
No.66	Contact Tank	Shariati	Existing	900m3/h	x	130kW	x	4	3	1	KOUSAR	NEWMAN	2	1								A						A	638 x 1		
No.67	Contact Tank	Qaleh Morghi	Future																												
No.68	Reservoir & Contact Tank	Valiasr	Existing	520m3/h	x	110kW	x	3	2	1	KOUSAR	NEWMAN	1	1	2	2*800		A	A		C	A						A	334 x 1	A	
No.69	Reservoir & Contact Tank	Ferdows	Existing	220m3/h	x	220kW	x	3	2	1	KOUSAR	NEWMAN	2	1								A						A	667 x 1		
No.70	Distribution Reservoir	17th Shahrivar	Future																												
No.71	Distribution Reservoir	Tehran Pars Treatment Plant	Existing	640m3/h	x	110kW	x	3	2	1	KOUSAR	NEWMAN	2	1								A						A	334 x 1		
No.72	Distribution Reservoir	Saadatabad	Existing	920m3/h 500m3/h	x x	325kW 220kW	x x	4 2	3 1	2	KOUSAR KOUSAR	US MOTOR NEWMAN	2	1								A						A	2308 x 1		
No.73	Contact Tank	Yaftabad	Existing	2,700m3/h 2,400m3/h 1,200m3/h	x x x	315kW 315kW 330kW	x x x	2 2 1	2 1 1	1	KSB KSB KSB	SIEMENS SIEMENS SIEMENS	1	2	4	2*1000 +1250+250		A	A		C							A	2308 x 1	C	
No.74	Distribution Reservoir	Lower Aqdasieh	Existing	500m3/h	x	220kW	x	4	2	2	KOUSAR	NEWMAN	2	1								A						A	667 x 1		
No.75	Distribution Reservoir	Upper Aqdasieh	Existing	760m3/h	x	220kW	x	4	3	1	KOUSAR	NEWMAN	2	1								A						A	2308 x 1		
No.76	Break Pressure Tank	Tehran Pars Pressure Reducer	Existing	no pump																											
No.77	Distribution Reservoir	Upper Baqlazar	Not used	no pump																											
No.78	Distribution Reservoir	Lower Sohanak	Future																												
No.79	Distribution Reservoir	Upper Sohanak	Future																												
No.80	Distribution Reservoir	Lower Hesarak	Existing	820m3/h	x	265kW	x	5	4	1	KOUSAR	US MOTOR	2	1								A						A	2308 x 1		
No.81	Distribution Reservoir	Upper Hesarak	Existing	340m3/h	x	250kW	x	6	5	1	PUMPIRAN	JEMCO	2	1								A						A	2308 x 1		
No.82	Distribution Reservoir	Lower Kahrizak	Existing	820m3/h	x	220kW	x	2	1	1	KOUSAR	NEWMAN	2	1														A	334 x 1		
No.83	Distribution Reservoir	Upper Kahrizak	Under Construction																												
No.84	Distribution Reservoir	Lower Moradabad	Future																												
No.85	Distribution Reservoir	Upper Moradabad	Under Construction																												
No.86	Distribution Reservoir	Lower Hor	Future																												
No.87	Distribution Reservoir	Upper Hor	Future																												
No.88	Distribution Reservoir	Northern Mehrabad	Future																												
No.89	Distribution Reservoir	Freshfruit & Vegetable Square	Existing	no pump																											
No.90	Booster Station	Manzarieh Booster	Existing	145m3/h	x	18.5kW	x	2	1	1	PUMPIRAN	?	2	1								A						A	70 x 1		
No.91	Distribution Reservoir	Upper Aliabad	Existing	30m3/h	x	11kW	x	2	1	1	PUMPIRAN	?	2	1								A						A	45 x 1		
No.92	Clear Water Tank	1st Treatment Plant Reservoir	Existing	1,400m3/h	x	480kW	x	4	2	2	KSB	SIEMENS	1	2							C							A	2308 x 1	C	
No.93	Clear Water Tank	2nd Treatment Plant Reservoir	Existing	200m3/h 400m3/h	x x	100kW 200kW	x x	2 1	2 1	0	PUMPIRAN PUMPIRAN	? ?	2	1								A						A	638 x 1		
No.94	Clear Water Tank	3rd Treatment Plant Reservoir	Existing	no pump																											
No.95	Clear Water Tank	3rd Treatment plant	Existing	150m3/h 300m3/h	x x	55kW 55kW	x x	2 1	1 1	1	PUMPIRAN PUMPIRAN	? ?	2	1								A						A	271 x 1		
				1,000m3/h	x	132kW	x	3	3	0	KOUSAR	NEWMAN																			

Main Information of Existing Equipment

No.	Name of Facilities	Location	Existing / Future	Specification of Pump: Nominal Q[m3/h]	x P[kW] x	Num. total	Num. duty	Num. standby	Pump Manufacturer	Motor Manufacturer	receiving voltage [V] (1 : 20 [kV], 2 : 400 [V])	number of incoming cable	number of trans-former	capacity of transformer [kVA]
No.96	Contact Tank	Southern Tarasht	Existing	300m3/h	x 95kW x	2	0	2	KOUSAR	NEWMAN	2	1		
				900m3/h	x 115kW x	1	1	0	KOUSAR	NEWMAN				
No.97	Clear Water Tank	4th Treatment Plant Reservoir	Existing	no pump										
No.98	Distribution Reservoir	Jey Garrison	Future											
No.99	Clear Water Tank	5th Treatment Plant Reservoir	Existing	no pump										
No.100	Distribution Reservoir	3rd Treatment Plant	Existing	no pump										
No.101	Distribution Reservoir	Upper Hakimieh (ground level)	Existing	60m3/h	x 11kW x	1	1	0	PUMPIRAN	?	2	1		
No.102	Distribution Reservoir	Lower Hakimieh (ground level)	Existing	300m3/h	x 132kW x	2	2	1	PUMPIRAN	?	2	1		
				160m3/h	x 75kW x	1	1		KSB	?				
				120m3/h	x 55kW x	1			PUMPIRAN	?				
No.103	Distribution Reservoir	6th Treatment Plant	Future											
No.104	Booster Station	Gisha Boosters	Existing	see No.18										
No.105	Booster Station	Sepah Bank Boosters	Existing	200m3/h	x 132kW x	2	1	1	KOUSAR	NEWMAN	2	1		
				300m3/h	x 132kW x	1	1		KOUSAR	NEWMAN				
No.106	Elevated Tank	Hakimieh elevated Tank	Existing	no pump										
No.107	Elevated Tank	Soleymanieh elevated Tank	Not used	no pump										
No.108	Elevated Tank	Afsarieh elevated Tank	Not used	no pump										
No.109	Elevated Tank	Shahran elevated Tank	Existing	no pump										
No.110	Elevated Tank	17th Shahrivar elevated tank	Future											
No.111	Elevated Tank	Valiasr elevated Tank	Existing	no pump										
No.112	Elevated Tank	Ferdows elevated Tank	Existing	no pump										
No.113	Elevated Tank	3rd Treatment Plant	Existing	no pump										
No.114	Distribution Reservoir	Tarasht Pump Station	Existing	1,400m3/h	x 480kW x	1	1	0	KSB	SIEMENS	1	1	1	630
Chlorine Dosing Station														
-	Station No.4		Existing											
-	Station No.5		Existing											
-	Station No.7		Existing											
-	Station No.13		Existing											
-	Station No.19		Existing											
-	Station No.21		Existing											
-	Station No.22		out of work											
-	Station No.31		Existing											
-	Station No.33		Existing											
-	Station No.36		Existing											
-	Station No.40		Existing											
-	Station No.42		future											
-	Station No.53		out of work											
-	Station No.35		Existing											
-	Station No.65		Existing											
-	Station No.66		Existing											
-	Station No.68		Existing											
-	Station No.69		Existing											
-	Station No.89		Existing											
-	-	Tarasht Pump	Existing											
-	-	Southern Tarasht	Existing											
-	-	Said Abad	Existing											
-	-	Sadr shahrak	out of work											

Countermeasures on Equipment (A = Needs Countermeasure, B = Partly Needs Countermeasure, C = Already Countermeasured)

(1) Measures for Minimization of Damage Occurrence: No.1–No.8; (2) Measures for Minimization of Damage Effect: No.9–No.12

No.	Name of Facilities	Location	No.1 Surge Tank	No.2 Trans-former	No.3 Battery	No.4 UPS	No.5 Electrical Panel: High Tension	No.5 Electrical Panel: Low Tension	No.6 Flexible Pipe: Exp. J	No.6 Flexible Pipe: Fuel	No.7 Electric Post	No.8 Chlorine Cylinder	No.9 Anti-flowout Fence	No.10 Emergency Generator	No.10 Capacity [kVA]	No.11 Duplicate Incoming Cable	No.12 Chlorine Dosing Equipment
No.96	Contact Tank	Southern Tarasht	A					A						A	813 x 1		
No.97	Clear Water Tank	4th Treatment Plant Reservoir															
No.98	Distribution Reservoir	Jey Garrison															
No.99	Clear Water Tank	5th Treatment Plant Reservoir															
No.100	Distribution Reservoir	3rd Treatment Plant															
No.101	Distribution Reservoir	Upper Hakimieh (ground level)						A						A	58 x 1		
No.102	Distribution Reservoir	Lower Hakimieh (ground level)						A						A	638 x 1		
No.103	Distribution Reservoir	6th Treatment Plant															
No.104	Booster Station	Gisha Boosters															
No.105	Booster Station	Sepah Bank Boosters						A						A	638 x 1		
No.106	Elevated Tank	Hakimieh elevated Tank															
No.107	Elevated Tank	Soleymanieh elevated Tank															
No.108	Elevated Tank	Afsarieh elevated Tank															
No.109	Elevated Tank	Shahran elevated Tank															
No.110	Elevated Tank	17th Shahrivar elevated tank															
No.111	Elevated Tank	Valiasr elevated Tank															
No.112	Elevated Tank	Ferdows elevated Tank															
No.113	Elevated Tank	3rd Treatment Plant															
No.114	Distribution Reservoir	Tarasht Pump Station		A	A		C							A	813 x 1	A	
Chlorine Dosing Station																	
-	Station No.4											A					A
-	Station No.5											A					A
-	Station No.7											A					A
-	Station No.13											A					A
-	Station No.19											A					A
-	Station No.21											A					A
-	Station No.22																
-	Station No.31											A					A
-	Station No.33											A					A
-	Station No.36											A					A
-	Station No.40											A					A
-	Station No.42																
-	Station No.53																
-	Station No.35											A					A
-	Station No.65											A					A
-	Station No.66											A					A
-	Station No.68											A					A
-	Station No.69											A					A
-	Station No.89											A					A
-	-	Tarasht Pump										A					A
-	-	Southern Tarasht										A					A
-	-	Said Abad										A					A
-	-	Sadr shahrak															

Countermeasures on Equipment (1)

Item of Countermeasure	Support of Surge Tank
Proposed for	**Reservoir No.2, No.22, No.96**

1) Contents of Countermeasure

a) Mechanical Work:

Construction of Support

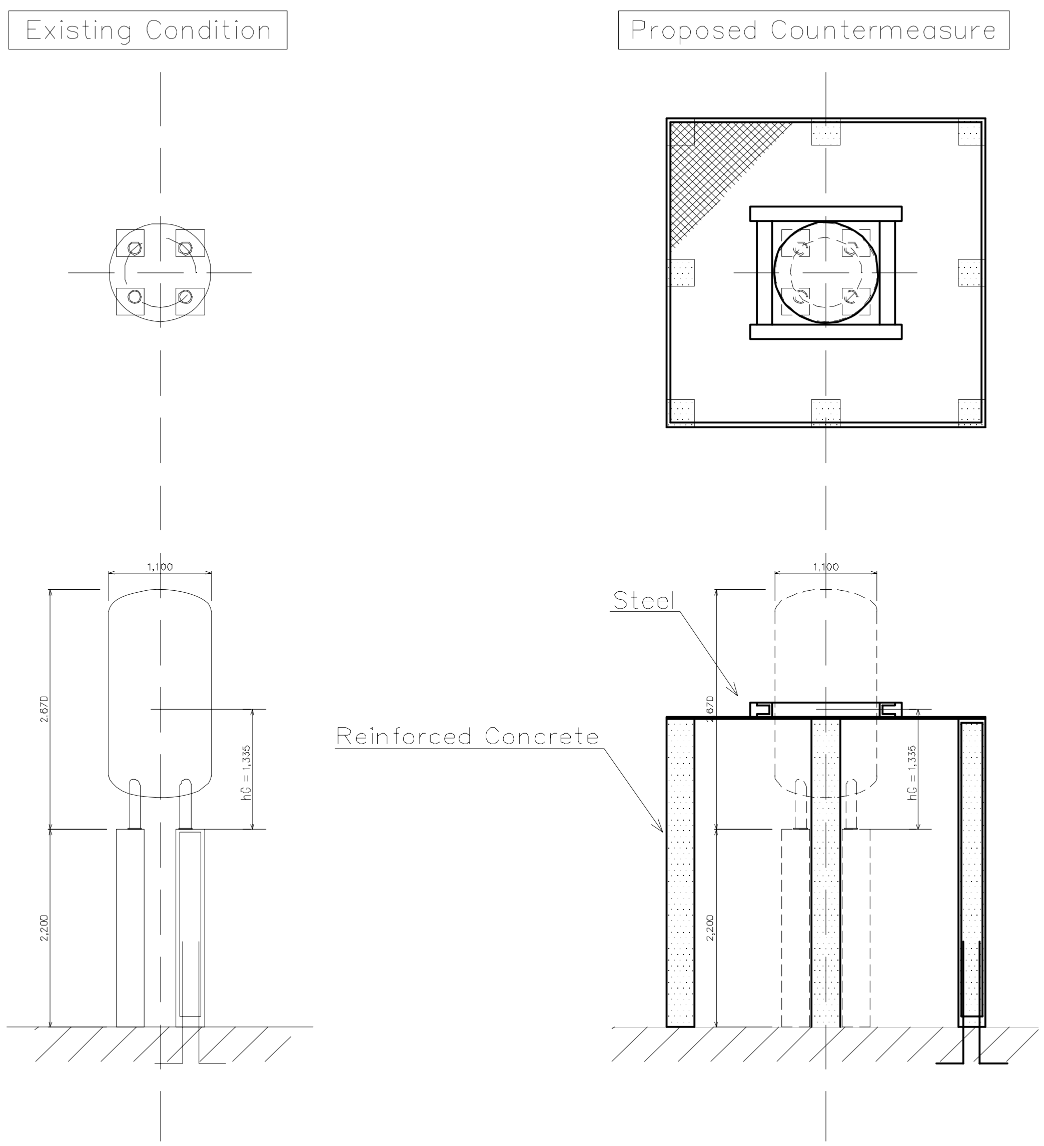
b) Electrical Work:

none

c) Other Work:

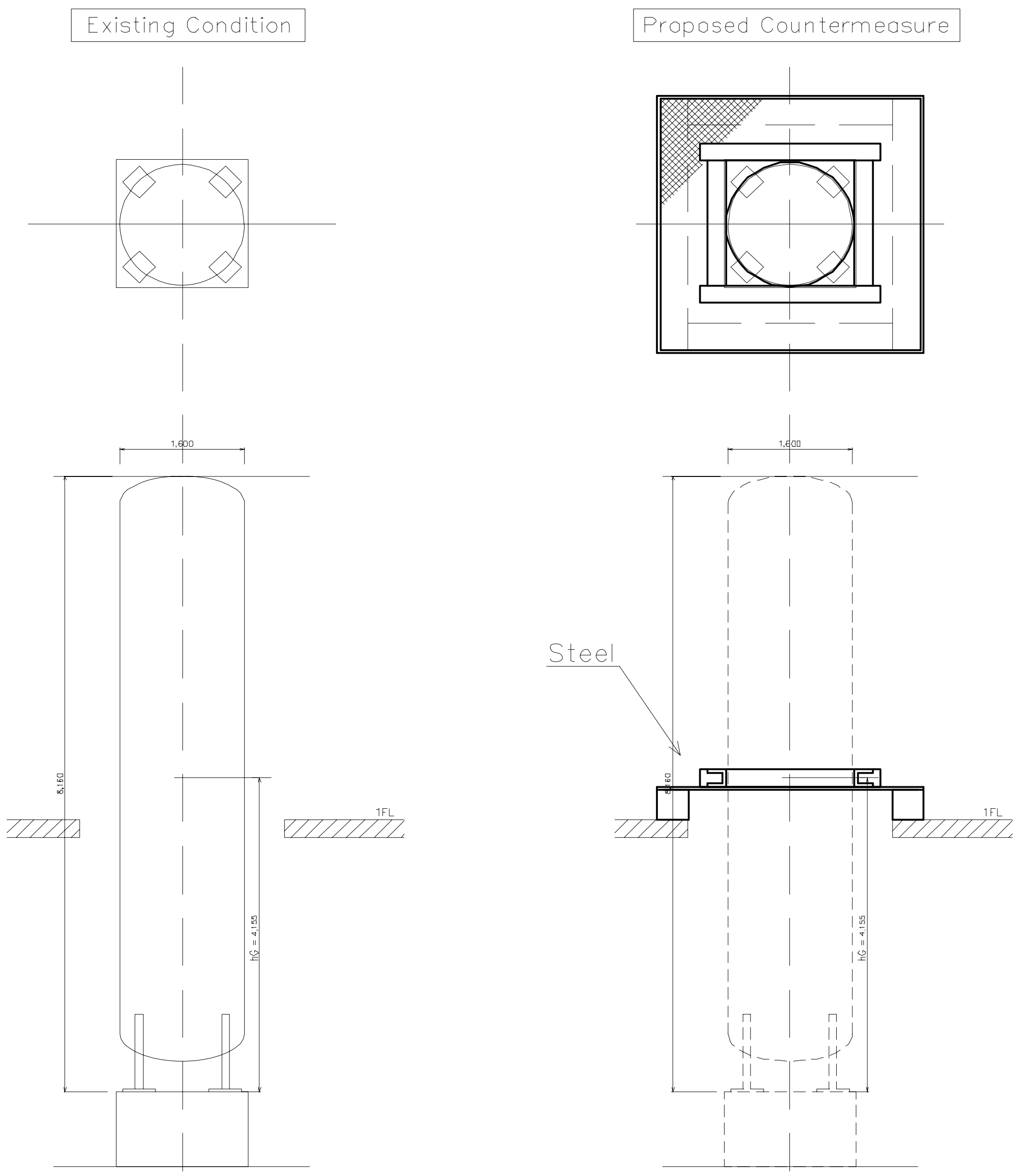
none

2) Countermeasure Plan at Reservoir No.22



Countermeasures on Equipment (1)

3) Countermeasure Plan at Reservoir No.2



4) Cost Estimate

Reservoir No.2	600 USD	(2 tanks)
Reservoir No.22	800 USD	(2 tanks)
Reservoir No.96	400 USD	(1 tank)
TOTAL	1,800 USD	

Countermeasures on Equipment (2) **(1/2)**

Item of Countermeasure	Fixation of Transformer
Proposed for	**WTP No.1, No.2, No.3&4, No.5, Reservoir No.1, No.2, No.13, No.14, No.15, No.16, No.17, No.19, No.20, No.21, No.22, No.24, No.25, No.26, No.40, No.52, No.56, No.57, No.58, No.65, No.68, No.73, No.114**

1) Contents of Countermeasure

a) Mechanical Work:

none

b) Electrical Work:

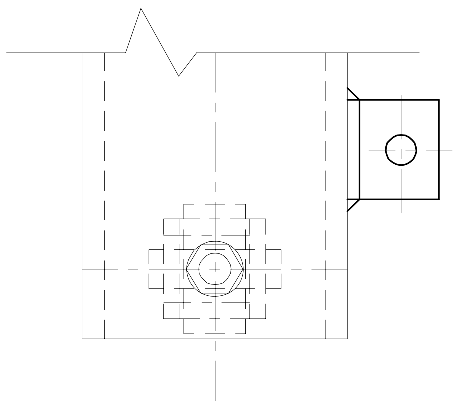
Installation of metal fitting, foundation bolt, or brace.

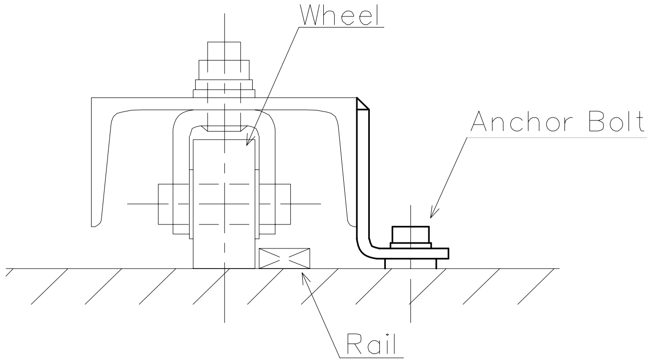
c) Other Work:

none

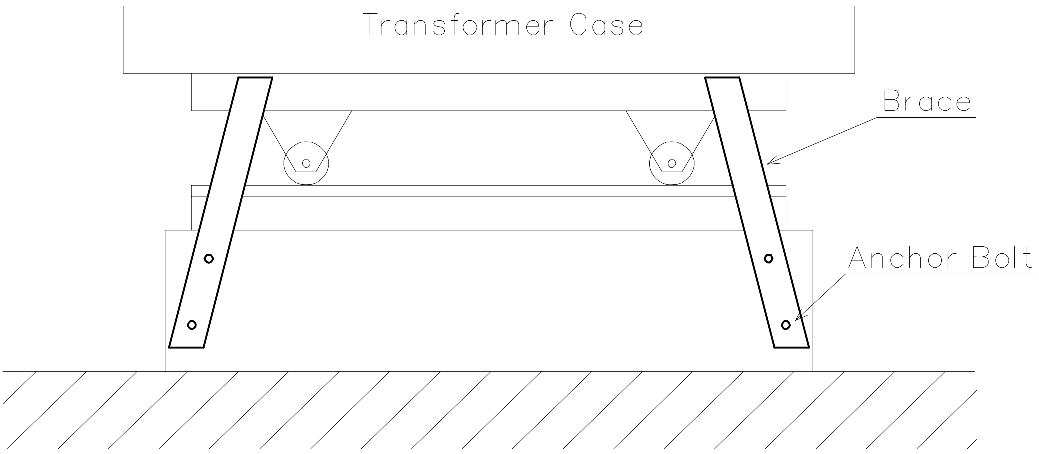
2) Countermeasure Plan at Typical WTP, Pumping Station:

[Alternative A]





[Alternative B]



3) Cost Estimate

Name of Facility	number of transformer	subtotal
WTP No.1	3	300 USD
WTP No.2	3	300 USD
WTP No.3&4	3	300 USD
WTP No.5	3	300 USD
Reservoir No.1	3	300 USD
Reservoir No.2	3	300 USD
Reservoir No.13	6	600 USD
Reservoir No.14	4	400 USD
Reservoir No.15	5	500 USD
Reservoir No.16	4	400 USD
Reservoir No.17	2	200 USD
Reservoir No.19	3	300 USD
Reservoir No.20	2	200 USD
Reservoir No.21	3	300 USD
Reservoir No.22	4	400 USD
Reservoir No.24	3	300 USD
Reservoir No.25	3	300 USD
Reservoir No.26	2	200 USD
Reservoir No.40	4	400 USD
Reservoir No.52	3	300 USD
Reservoir No.56	5	500 USD
Reservoir No.57	4	400 USD
Reservoir No.58	3	300 USD
Reservoir No.65	1	100 USD
Reservoir No.68	2	200 USD
Reservoir No.73	4	400 USD
Reservoir No.114	1	100 USD
TOTAL	86	8,600 USD

Countermeasures on Equipment (3)

Item of Countermeasure	Fixation of Battery
Proposed for	**WTP No.1, No.2, No.3&4, No.5, Reservoir No.1, No.2, No.13, No.14, No.15, No.16, No.17, No.19, No.20, No.21, No.22, No.24, No.25, No.26, No.40, No.52, No.56, No.57, No.58, No.65, No.68, No.73, No.114**

1) Contents of Countermeasure

a) Mechanical Work:

none

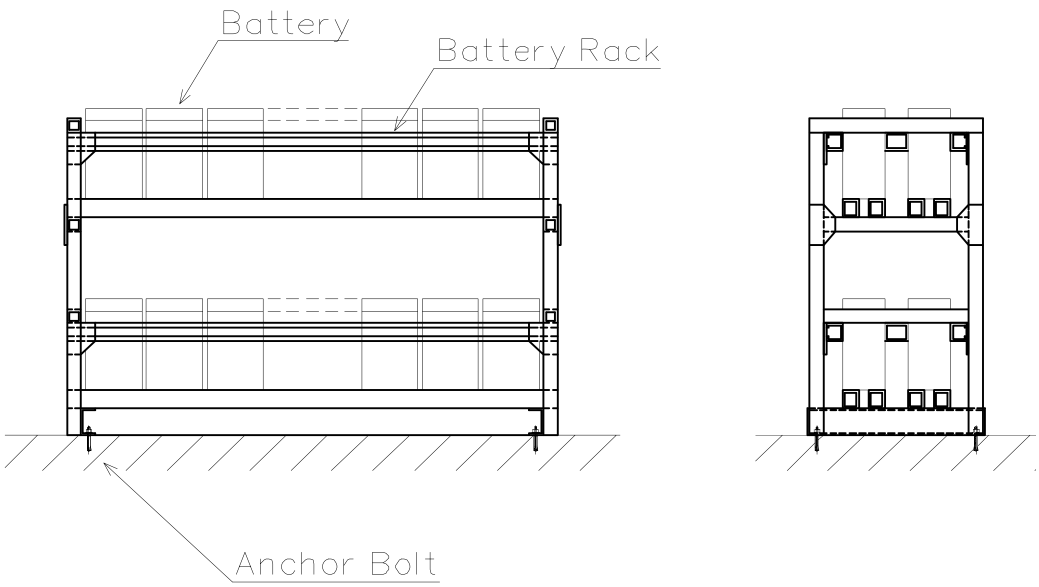
b) Electrical Work:

Installation of battery rack, foundation bolt.

c) Other Work:

none

2) Countermeasure Plan at Typical WTP, Pumping Station, Reservoir:



3) Cost Estimate

Name of Facility	subtotal
WTP No.1	150 USD
WTP No.2	150 USD
WTP No.3&4	150 USD
WTP No.5	150 USD
Reservoir No.1	150 USD
Reservoir No.2	150 USD
Reservoir No.13	150 USD
Reservoir No.14	150 USD
Reservoir No.15	150 USD
Reservoir No.16	150 USD
Reservoir No.17	150 USD
Reservoir No.19	150 USD
Reservoir No.20	150 USD
Reservoir No.21	150 USD
Reservoir No.22	150 USD
Reservoir No.24	150 USD
Reservoir No.25	150 USD
Reservoir No.26	150 USD
Reservoir No.40	150 USD
Reservoir No.52	150 USD
Reservoir No.56	150 USD
Reservoir No.57	150 USD
Reservoir No.58	150 USD
Reservoir No.65	150 USD
Reservoir No.68	150 USD
Reservoir No.73	150 USD
Reservoir No.114	150 USD
TOTAL	4,050 USD

Countermeasures on Equipment (4)

Item of Countermeasure	Fixation of UPS
Proposed for	**WTP No.1, No.2, No.3&4, No.5**

1) Contents of Countermeasure

a) Mechanical Work:

none

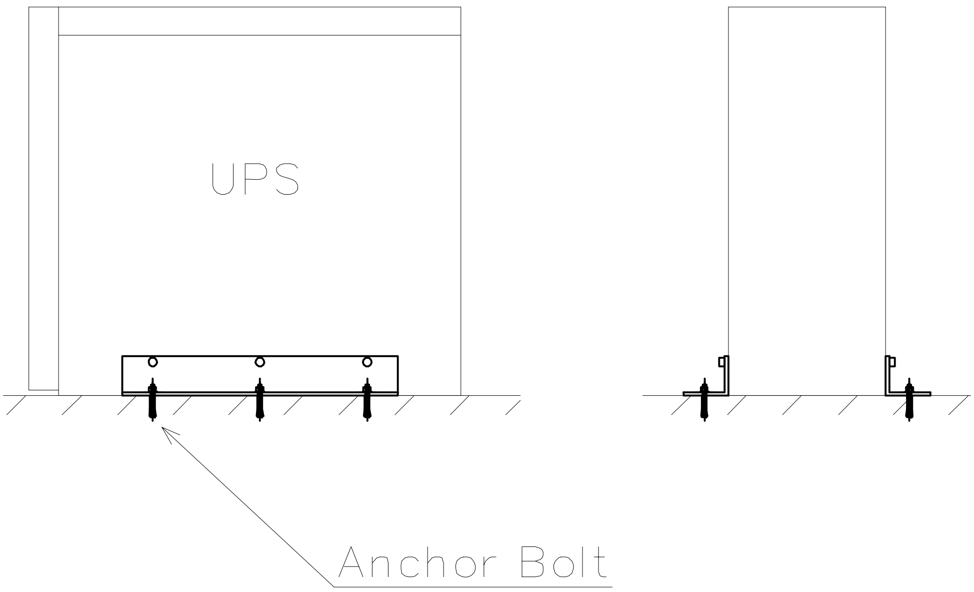
b) Electrical Work:

Installation of metal fitting, foundaition bolt.

c) Other Work:

none

2) Countermeasure Plan at Typical WTP:



3) Cost Estimate

WTP No.1	50 USD
WTP No.2	50 USD
WTP No.3&4	50 USD
WTP No.5	50 USD
TOTAL	200 USD

Countermeasures on Equipment (5)

Item of Countermeasure	Fixation of 400V Pump Panel
Proposed for	**Almost all the facilities, especially 400V pumping stations**

1) Contents of Countermeasure

a) Mechanical Work:

none

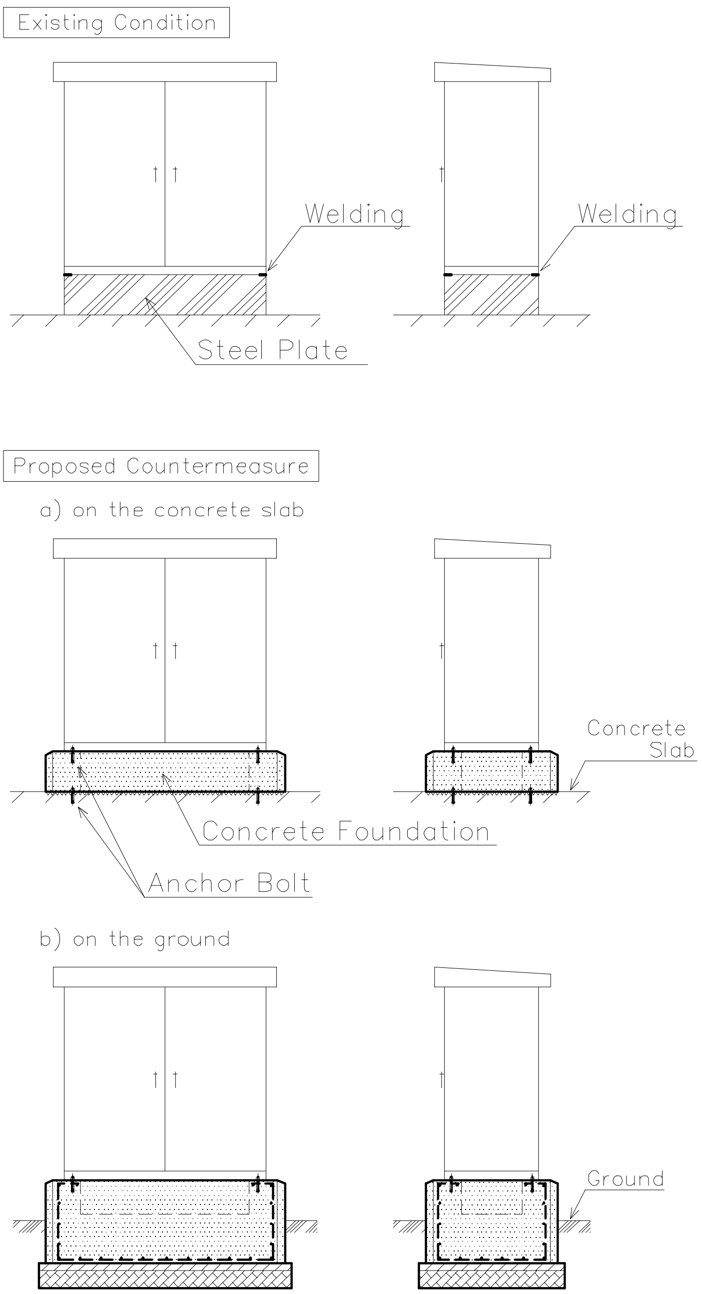
b) Electrical Work:

Construction of concrete foundation, installation of anchor bolt.

c) Other Work:

none

2) Countermeasure Plan at Typical Pumping Station:



Countermeasures on Equipment (5)

3) Cost Estimate

Name of Facility	number of 400V pump	subtotal	
Reservoir No.8	3	600 USD	
Reservoir No.12	3	600 USD	
Reservoir No.13	12	2,400 USD	
Reservoir No.27	3	600 USD	
Reservoir No.28	3	600 USD	
Reservoir No.32	5	1,000 USD	
Reservoir No.34	3	600 USD	
Reservoir No.36	6	1,200 USD	
Reservoir No.37	7	1,400 USD	
Reservoir No.38	4	800 USD	
Reservoir No.43	4	800 USD	
Reservoir No.59	5	1,000 USD	
Reservoir No.65	4	800 USD	
Reservoir No.66	4	800 USD	
Reservoir No.68	3	600 USD	
Reservoir No.69	3	600 USD	
Reservoir No.71	3	600 USD	
Reservoir No.72	6	1,500 USD	NOTE)
Reservoir No.74	4	800 USD	
Reservoir No.75	4	800 USD	
Reservoir No.80	5	1,000 USD	
Reservoir No.81	6	1,200 USD	
Reservoir No.90	2	400 USD	
Reservoir No.91	2	400 USD	
Reservoir No.93	3	600 USD	
Reservoir No.95	3	600 USD	
Reservoir No.96	6	1,200 USD	
Reservoir No.101	1	200 USD	
Reservoir No.102	4	800 USD	
Reservoir No.105	3	600 USD	
Well Pump	400	80,000 USD	
TOTAL	503	105,100 USD	

NOTE)
Countermeasure of Reservoir No.72 includes reinforcement of steel stage.

Countermeasures on Equipment (6-1)

Item of Countermeasure	Installation of Flexible Pipe 1 (Expansion Joint)
Proposed for	**WTP No.1, No.2, No.3&4**

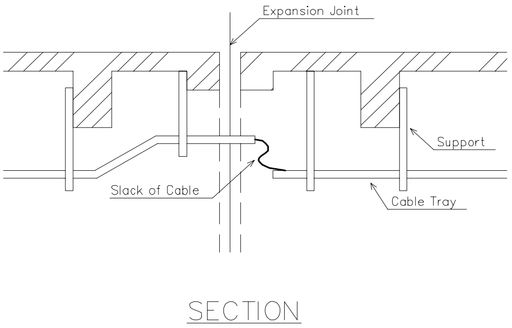
1) Contents of Countermeasure

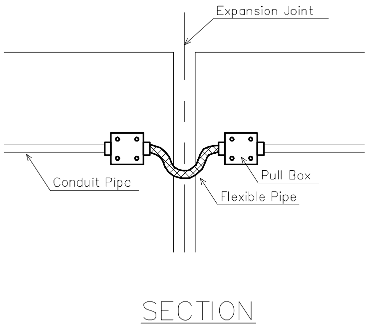
a) Mechanical Work:
Installation of flexible pipe

b) Electrical Work:
Installation of flexible pipe

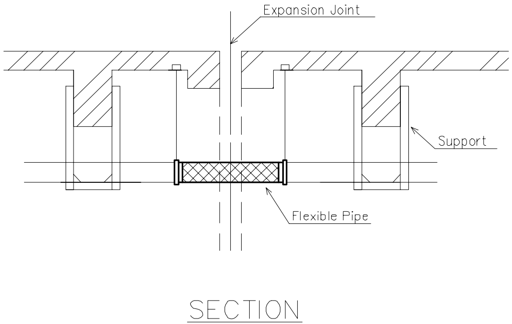
c) Other Work:
none

2) Countermeasure Plan at Typical WTP:





Proposed Cabling Work at Expansion Joint Portion



Proposed Piping Work at Expansion Joint Portion

3) Cost Estimate

WTP No.1	400 USD
WTP No.2	400 USD
WTP No.3&4	400 USD
TOTAL	1,200 USD

Appendix-6.3 **Countermeasures on Equipment (6-2)** **(1/1)**

Item of Countermeasure	Installation of Flexible Pipe 2 (Fuel Feeding Pipe)
Proposed for	**WTP No.1, No.2, No.3&4, No.5**

1) Contents of Countermeasure

a) Mechanical Work:

none

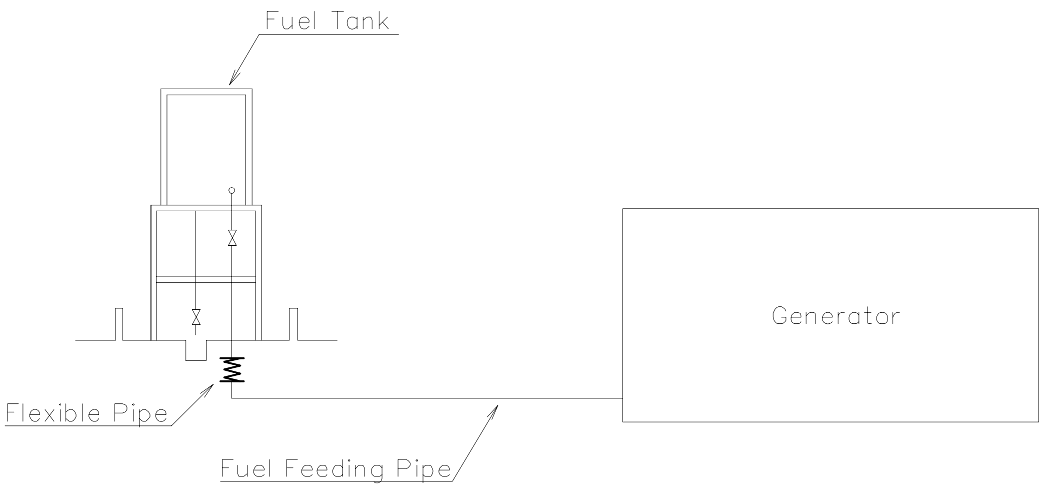
b) Electrical Work:

Installation of flexible pipe

c) Other Work:

none

2) Countermeasure Plan at Typical Generator Equipment:



3) Cost Estimate

Name of Facility	number of fuel tank	subtotal
Bilaghan Intake	3	1,800 USD
WTP No.1	5	3,000 USD
WTP No.2	2	1,200 USD
WTP No.3&4	2	1,200 USD
WTP No.5	1	600 USD
TOTAL		7,800 USD

Countermeasures on Equipment (7)

Item of Countermeasure	Electric Post
Proposed for	**Reservoir No.22**

1) Contents of Countermeasure

a) Mechanical Work:

none

b) Electrical Work: **(by Ministry of Energy)**

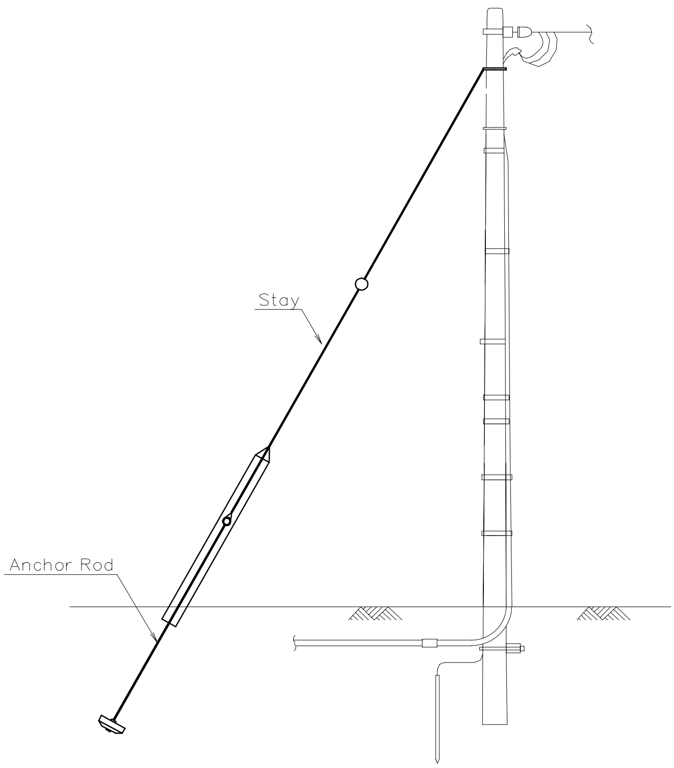
Installation of stay.

Or underground wiring instead of overhead wiring.

c) Other Work:

none

2) Countermeasure Plan at Reservoir No.22:



3) Cost Estimate

Reservoir No.22	100 USD
TOTAL	100 USD

Countermeasures on Equipment (8)

Item of Countermeasure	Fixation of Chlorine Cylinder
Proposed for	**WTP No.1, No.2, No.3, All the Chlorine Dosing Stations**

1) Contents of Countermeasure

a) Mechanical Work:

Construction of Support Stand for Chlorine Container.

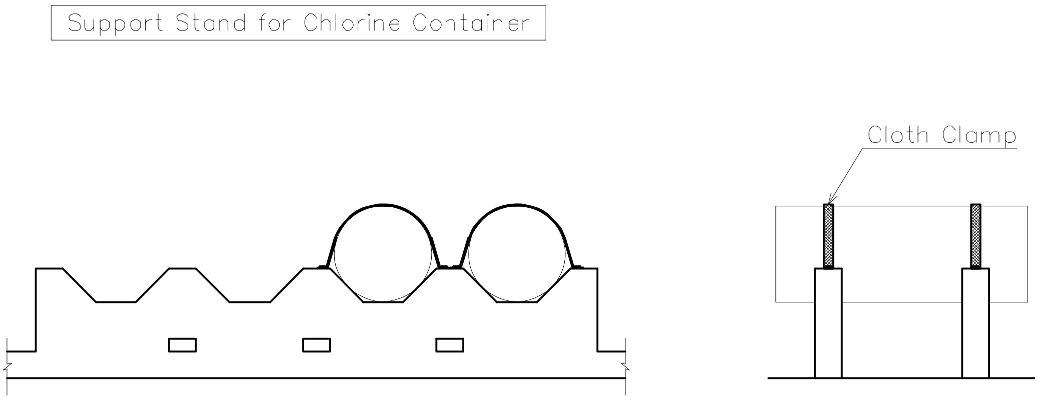
b) Electrical Work:

none

c) Other Work:

none

2) Countermeasure Plan at Typical WTP, Chlorine Dosing Station:



3) Cost Estimate

Bilaghan Intake	1,000
WTP No.1	1,000
WTP No.2	1,000
WTP No.3	1,000
Station No.4	1,000
Station No.5	1,000
Station No.7	1,000
Station No.13	1,000
Station No.19	1,000
Station No.21	1,000
Station No.22	out of work
Station No.31	1,000
Station No.33	1,000
Station No.36	1,000
Station No.40	1,000
Station No.42	future
Station No.53	out of work
Station No.35	1,000
Station No.65	1,000
Station No.66	1,000
Station No.68	1,000
Station No.69	1,000
Station No.89	1,000
Tarasht Pump	1,000
Southern Tarasht	1,000
Said Abad	1,000
Sadr shahrak	out of work
TOTAL	23,000

Appendix-6.3

Countermeasures on Equipment (9)

(1/1)

Item of Countermeasure	Construction of Anti-flowout Fence
Proposed for	**WTP No.1, No.2, No.3&4, No.5**

1) Contents of Countermeasure

a) Mechanical Work:

none

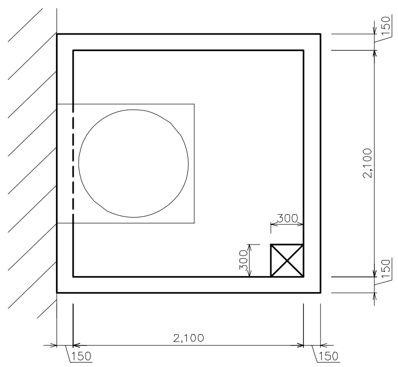
b) Electrical Work:

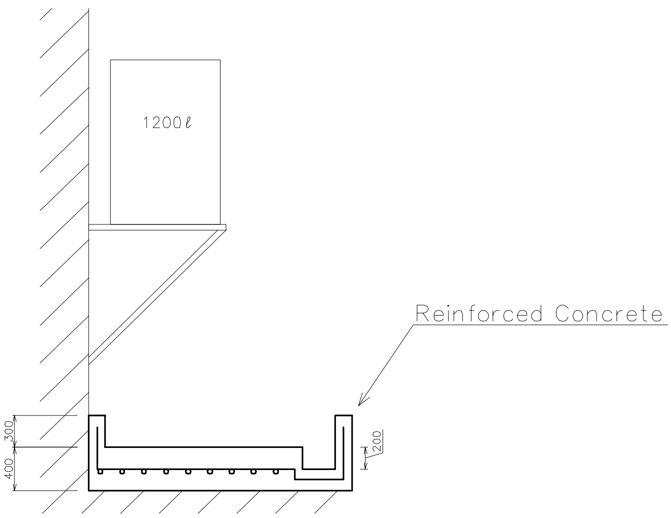
Construction of Anti-flowout Fence.

c) Other Work:

none

2) Countermeasure Plan at WTP No.1:





Basic Calculation

1) volume of fuel tank x allowance rate
= 1.2 x 1.1
= 1.32 [m3] (a)

2) volume of anti-flowout fence
= W2.1m x D2.1m x H0.3m
=1.323 [m3] (b)

3) comparison between (a) and (b)
(a) < (b) ==> OK

3) Cost Estimate

Name of Facility	number of fuel tank	subtotal
Bilaghan Intake	3	900 USD
WTP No.1	5	1,500 USD
WTP No.2	2	600 USD
WTP No.3&4	2	600 USD
WTP No.5	1	300 USD
TOTAL		3,900 USD

Countermeasures on Equipment (10)

Item of Countermeasure	Installation of Emergency Generator
Proposed for	**All the Pumping Stations**

1) Contents of Countermeasure

a) Mechanical Work:

none

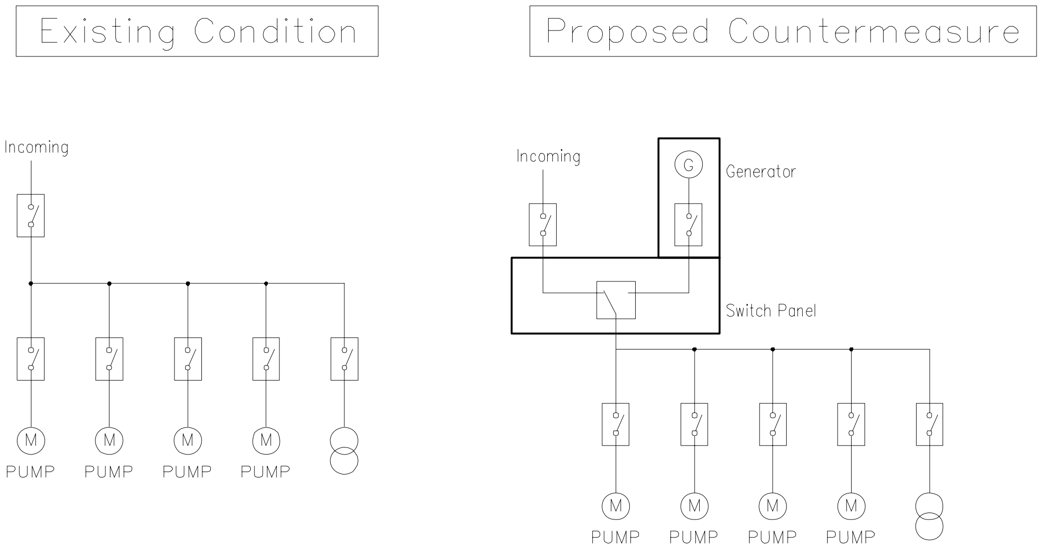
b) Electrical Work:

Installation of emergency generator set, fuel tank
Installation of Switch Panel
Wiring

c) Other Work:

Construction of generator building. (If necessary)

2) Countermeasure Plan at Typical Pumping Station:



3) Cost Estimate

	capacity of generator [kVA]	capacity of fuel tank [L]	price of generator [USD]	price of fuel tank [USD]	price of Switch Panel [USD]	subtotal [USD]
Reservoir No.1	2,308 x2	60,000	2,455,000	8,700	30,000	2,493,700
Reservoir No.2	2,308 x1	8,000	1,228,000	1,400	30,000	1,259,400
Reservoir No.8	667 x1	5,000	238,000	1,100	30,000	269,100
Reservoir No.12	638 x1	4,000	224,000	1,000	30,000	255,000
Reservoir No.13	2,308 x2	60,000	2,455,000	8,700	30,000	2,493,700
Reservoir No.14	2,308 x2	40,000	2,455,000	6,800	30,000	2,491,800
Reservoir No.15	2,308 x2	50,000	2,455,000	7,900	30,000	2,492,900
Reservoir No.16	2,308 x1	18,000	1,228,000	3,200	30,000	1,261,200
Reservoir No.17	2,308 x1	18,000	1,228,000	3,200	30,000	1,261,200
Reservoir No.19	2,308 x1	18,000	1,228,000	3,200	30,000	1,261,200
Reservoir No.20	2,308 x1	10,000	1,228,000	2,300	30,000	1,260,300

Countermeasures on Equipment (10) (2/2)

Reservoir No.21	2,308 x3	60000x3	3,683,000	26,000	30,000	3,739,000
Reservoir No.22	2,308 x2	50,000	2,455,000	7,900	30,000	2,492,900
Reservoir No.24	638 x1	5,000	224,000	1,100	30,000	255,100
Reservoir No.25	897 x1	7,000	477,000	1,300	30,000	508,300
Reservoir No.26	450 x1	3,500	97,000	900	30,000	127,900
Reservoir No.27	450 x1	3,500	97,000	900	30,000	127,900
Reservoir No.28	211 x1	1,900	59,000	700	30,000	89,700
Reservoir No.32	450 x1	4,000	97,000	1,000	30,000	128,000
Reservoir No.34	450 x1	3,500	97,000	900	30,000	127,900
Reservoir No.36	2,308 x1	12,000	1,228,000	2,400	30,000	1,260,400
Reservoir No.37	2,308 x1	15,000	1,228,000	2,900	30,000	1,260,900
Reservoir No.38	667 x1	5,000	238,000	1,100	30,000	269,100
Reservoir No.40	638 x1	5,000	224,000	1,100	30,000	255,100
Reservoir No.43	667 x1	5,000	238,000	1,100	30,000	269,100
Reservoir No.52	667 x1	5,000	253,000	1,100	30,000	284,100
Reservoir No.56	2,308 x4	60,000x4	4,911,000	34,700	30,000	4,975,700
Reservoir No.57	2,308 x3	60,000x2	3,683,000	17,300	30,000	3,730,300
Reservoir No.58	2,308 x3	60,000x2	3,683,000	17,300	30,000	3,730,300
Reservoir No.59	2,308 x1	18,000	1,228,000	3,200	30,000	1,261,200
Reservoir No.65	2,308 x1	8,000	1,228,000	1,400	30,000	1,259,400
Reservoir No.66	638 x1	5,000	224,000	1,100	30,000	255,100
Reservoir No.68	334 x1	3,000	74,000	800	30,000	104,800
Reservoir No.69	667 x1	5,000	238,000	1,100	30,000	269,100
Reservoir No.71	334 x1	3,000	74,000	800	30,000	104,800
Reservoir No.72	2,308 x1	13,000	1,228,000	2,600	30,000	1,260,600
Reservoir No.73	2,308 x1	15,000	1,228,000	2,900	30,000	1,260,900
Reservoir No.74	667 x1	5,000	238,000	1,100	30,000	269,100
Reservoir No.75	2,308 x1	8,000	1,228,000	1,400	30,000	1,259,400
Reservoir No.80	2,308 x1	15,000	1,228,000	2,900	30,000	1,260,900
Reservoir No.81	2,308 x1	15,000	1,228,000	2,900	30,000	1,260,900
Reservoir No.82	334 x1	3,000	74,000	800	30,000	104,800
Reservoir No.90	70 x1	1,000	22,000	500	30,000	52,500
Reservoir No.91	45 x1	1,000	15,000	500	30,000	45,500
Reservoir No.92	2,308 x1	12,000	1,228,000	2,400	30,000	1,260,400
Reservoir No.93	638 x1	5,000	224,000	1,100	30,000	255,100
Reservoir No.95	271 x1	2,500	62,000	800	30,000	92,800
Reservoir No.96	813 x1	6,000	376,000	1,200	30,000	407,200
Reservoir No.101	58 x1	1,000	18,000	500	30,000	48,500
Reservoir No.102	638 x1	4,000	224,000	1,000	30,000	255,000
Reservoir No.105	638 x1	3,500	224,000	900	30,000	254,900
Reservoir No.114	813 x1	6,000	376,000	1,200	30,000	407,200
TOTAL			51,681,000	200,300	1,560,000	53,441,300

Countermeasures on Equipment (11) (1/1)

Item of Countermeasure	Duplicate Incoming Cable
Proposed for	**Pumping Station No.16, No.52, No.68, No.114**

1) Contents of Countermeasure

a) Mechanical Work:

none

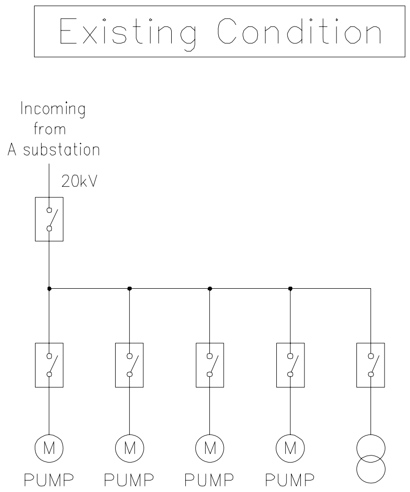
b) Electrical Work:

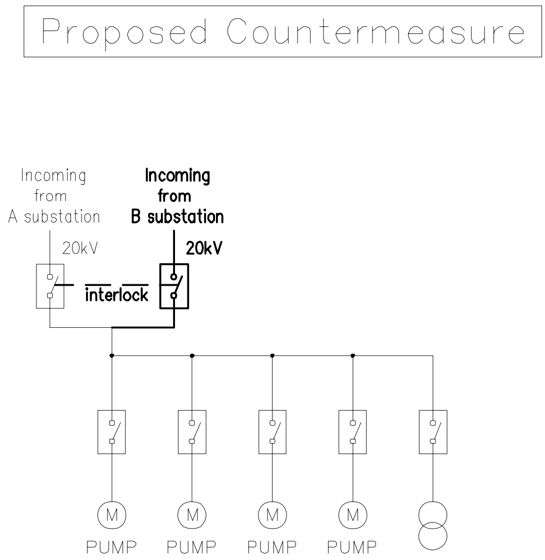
Construction of electric pole.
Installation of circiuit breaker panel.
Wiring

c) Other Work:

none

2) Countermeasure Plan at Typical Pumping Station:





3) Cost Estimate

Reservoir No.16	30,000 USD
Reservoir No.52	30,000 USD
Reservoir No.68	30,000 USD
Reservoir No.114	30,000 USD
TOTAL	120,000 USD

Countermeasures on Equipment (12)

Item of Countermeasure	Chlorine Dosing Equipment
Proposed for	**All the WTPs, Chlorine Dosing Stations**

1) Contents of Countermeasure

a) Mechanical Work:

Installation of Neutralization Equipment, Gas Shutoff Valve.
or, Installation of sodium hypochlorite dosing system.

b) Electrical Work:

Wiring, etc.

c) Other Work:

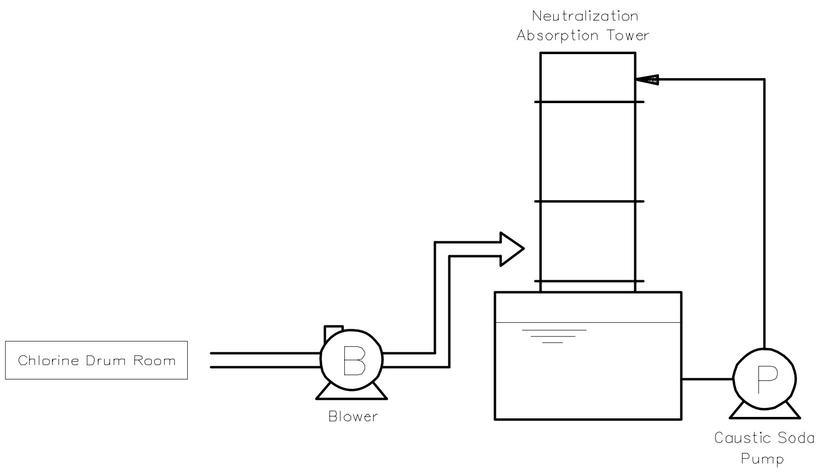
Construction of building. (If necessary)

2) Countermeasure Plan at Typical WTP, Chlorine Dosing Station:

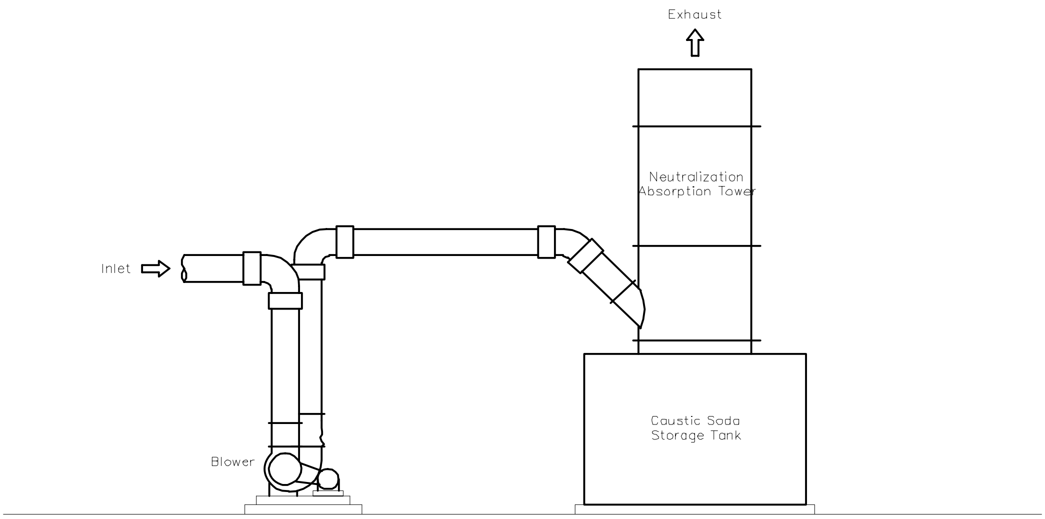
[Alternative A] Neutralization Equipment, Gas Shutoff Valve

Neutralization Equipment

1) Basic Flow Diagram



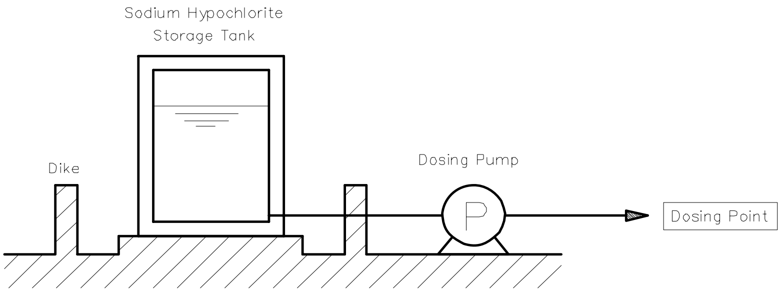
2) Basic Layout



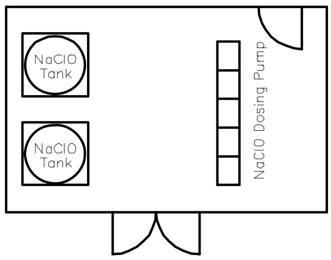
[Alternative B] Purchased Sodium Hypochlorite System

Purchased Sodium Hypochlorite

1) Basic Flow Diagram



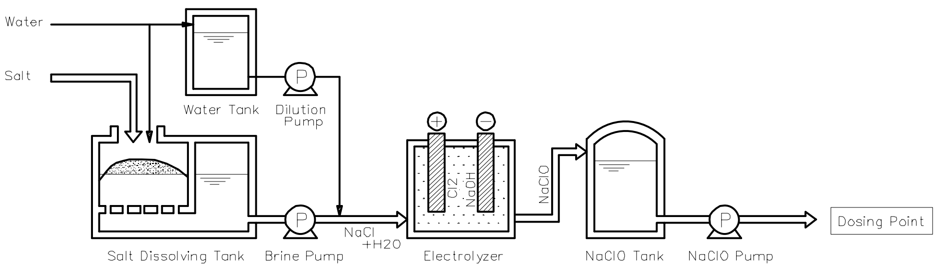
2) Basic Layout



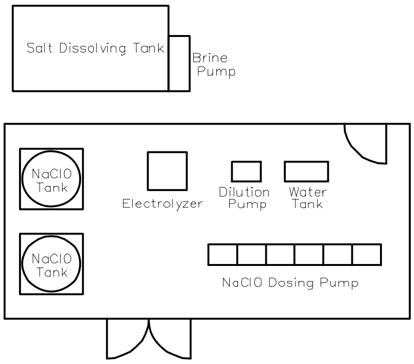
[Alternative C] On-site Generation of Sodium Hypochlorite System

On-site Generation of Sodium Hypochlorite

1) Basic Flow Diagram



2) Basic Layout



3) Cost Estimate

Chlorine Dosing Equipment

Station No.	Station Name	Existing Dosing Capacity (Liquified Chlorine Gas)		Chlorine Dosing Equipment System: Alternative A : Neutralization Equipment				Sodium Hypochlorite System: Alternative B : Purchased Sodium Hypochlorite System						Alternative C : On-site Generation of Sodium Hypochlorite System					
		Normal [gr/h]	Maximum [gr/h]	Neutralization Capacity [kg/h]	Installation Area [m2]	Equipment Cost [USD]	Maintenance Cost [USD/year]	Dosing Capacity [m3 ×set]	Installation Area [m2]	Consumption of Sodium Hypochlorite (12%)[kg/day]	Consumption of Electricity [kWh/day]	Equipment Cost [USD]	Maintenance Cost [USD/year]	Production Capacity [kg/day×set]	Installation Area [m2]	Consumption of Salt [kg/day]	Consumption of Electricity [kWh/day]	Equipment Cost [USD]	Maintenance Cost [USD/year]
	Bilaghan Intake	33,334	66,667	100	20	300,000	16,000	30m3 x 4	109	6,667	10	302,000	38,000	1200kg/d x 3	655	2,400	3,849	9,403,000	522,000
	WTP No.1	4,705	9,410	50	16	130,000	7,000	6m3 x 3	50	941	10	149,000	37,000	150kg/d x 3	83	339	567	2,002,000	115,000
	WTP No.2	6,424	12,848	50	16	130,000	7,000	10m3 x 3	63	1,285	10	175,000	37,000	200kg/d x 3	158	463	761	2,714,000	141,000
	WTP No.3&4	60,378	120,756	500	32	458,000	23,000	30m3 x 6	163	12,076	36	453,000	40,000	1200kg/d x 4	873	4,347	6,943	12,538,000	685,000
	WTP No.5	12,121	24,242	50	16	130,000	7,000	15m3 x 3	70	2,424	10	194,000	37,000	400kg/d x 3	264	873	1,403	3,762,000	207,000
Station No.4		400	700	50	16	130,000	7,000	1m3 x 2	18	80	10	88,000	36,000	25kg/d x 2	16	29	62	604,000	52,000
Station No.5		750	750	50	16	130,000	7,000	3m3 x 2	26	150	10	96,000	36,000	25kg/d x 2	16	54	109	604,000	52,000
Station No.7		1,700	3,500	50	16	130,000	7,000	6m3 x 2	34	340	10	113,000	36,000	100kg/d x 2	41	122	205	1,055,000	76,000
Station No.13		1,700	3,000	50	16	130,000	7,000	6m3 x 2	34	340	10	113,000	36,000	100kg/d x 2	41	122	205	1,055,000	76,000
Station No.19		950	1,530	50	16	130,000	7,000	3m3 x 2	26	190	10	96,000	36,000	50kg/d x 2	28	68	124	777,000	61,000
Station No.21		1,100	2,500	50	16	130,000	7,000	3m3 x 2	26	220	10	96,000	36,000	100kg/d x 2	41	79	136	1,055,000	76,000
Station No.22		out of work	out of work																
Station No.31		350	1,000	50	16	130,000	7,000	1m3 x 2	18	70	10	88,000	36,000	25kg/d x 2	16	25	56	604,000	52,000
Station No.33		3,800	7,800	50	16	130,000	7,000	6m3 x 3	50	760	10	133,000	36,000	200kg/d x 2	106	274	465	1,809,000	105,000
Station No.36		1,000	1,500	50	16	130,000	7,000	3m3 x 2	26	200	10	96,000	36,000	50kg/d x 2	28	72	130	777,000	61,000
Station No.40		600	1,000	50	16	130,000	7,000	3m3 x 2	26	120	10	96,000	36,000	25kg/d x 2	16	43	89	604,000	52,000
Station No.42		future	future																
Station No.53		out of work	out of work																
Station No.35		10,000	15,000	50	16	130,000	7,000	15m3 x 3	70	2,000	10	178,000	36,000	400kg/d x 2	176	720	1,164	2,508,000	149,000
Station No.65		550	800	50	16	130,000	7,000	3m3 x 2	26	110	10	96,000	36,000	25kg/d x 2	16	40	82	604,000	52,000
Station No.66		1,000	1,500	50	16	130,000	7,000	3m3 x 2	26	200	10	96,000	36,000	50kg/d x 2	28	72	130	777,000	61,000
Station No.68		250	1,000	50	16	130,000	7,000	1m3 x 2	18	50	10	88,000	36,000	25kg/d x 2	16	18	43	604,000	52,000
Station No.69		600	1,000	50	16	130,000	7,000	3m3 x 2	26	120	10	96,000	36,000	25kg/d x 2	16	43	89	604,000	52,000
Station No.89		300	600	50	16	130,000	7,000	1m3 x 2	18	60	10	88,000	36,000	25kg/d x 2	16	22	49	604,000	52,000
-	Tarasht Pump	1,000	2,000	50	16	130,000	7,000	3m3 x 2	26	200	10	96,000	36,000	50kg/d x 2	28	72	130	777,000	61,000
-	Southern Tarasht	1,800	3,500	50	16	130,000	7,000	6m3 x 2	34	360	10	113,000	36,000	100kg/d x 2	41	130	217	1,055,000	76,000
-	Said Abad	0.05	0.25	50	16	130,000	7,000	-						-	-	-	-		
-	Sadr shahrak	out of work	out of work																
TOTAL						3,618,000	193,000					3,139,000	837,000					46,896,000	2,888,000

Note) Each cost was calculated using the price of Japanese Product.

APPENDIX- 7

Manual for Seismic Diagnosis
of
Facilities and Equipment

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
TEHRAN PROVINCIAL
WATER AND WASTEWATER COMPANY (TWWC)

THE STUDY ON WATER SUPPLY SYSTEM
RESISTANT TO EARTHQUAKES
IN TEHRAN MUNICIPALITY
IN
THE ISLAMIC REPUBLIC OF IRAN

MANUAL FOR SEISMIC DIAGNOSIS
OF FACILITIES AND EQUIPMENT

2006

NIHON SUIDO CONSULTANTS CO., LTD
IN ASSOCIATION WITH
TOKYO ENGINEERING CONSULTANTS CO., LTD

TABLE OF CONTENTS OF MANUAL FOR SEISMIC DIAGNOSIS OF FACILITIES STRUCTURE AND EQUIPMENT

MANUAL FOR SEISMIC DIAGNOSIS
OF FACILITIES STRUCTURE AND EQUIPMENT

1. GENERAL

1.1 Purpose of this Manual

This Manual shall be extensively helpful for Iranian authorities and engineers to efficiently investigate and carry out the seismic diagnosis of facilities structure and equipment included in the Tehran water supply system from now on.

1.2 Scope of Application

This Manual shall be applied for the seismic diagnosis of facilities present in Tehran water supply system.

(Comment)

As this Manual for Seismic Diagnosis has been prepared on the basis of JICA Study on Tehran water supply facilities, some diagnostic tables refer in particular to the characteristics of Tehran. Therefore, this Manual shall be applied specifically for the seismic diagnosis of Tehran water supply system.

1.3 Contents of Manual

Seismic diagnosis consists of two steps of diagnoses, viz.1) Preliminary diagnosis and 2) Detailed diagnosis, and could be composed of the following six elements.

- Site survey of structural facilities
- Site survey of non- structural members of building
- Site survey of mechanical and electrical equipment
- Damage estimations for structure by DTSC
- Damage estimations for tank and building through Structural analysis
- Damage estimations for mechanical and electrical equipment through Strength analysis of foundation bolt

(Comment)

The reason for carrying out the two steps of diagnoses viz.1) Primary diagnosis and 2) Detailed diagnosis, is attributed to the fact that sometimes it is difficult to find each facility's aseismicity specifically through only preliminary diagnosis, and therefore detailed diagnosis of facilities is performed.

The Study Team proposes the elements of seismic diagnosis of facility structures and equipment, in the form of flow chart for seismic diagnosis, as shown in **Table-1**. This chart implies that in cases when sufficient data on design and soil conditions are not available, site survey is fairly important and close attention should be paid to visual inspections. In such cases, earthquake-resistant evaluation should be carried out by diagnostic table based on the results of visual inspections. Following this, structural analysis should be performed in order to verify the results obtained from diagnostic table. In Table 1, it is mentioned that the damage estimations of structures and equipment should be a part of the detailed diagnosis.

Table-1 FLOW CHRT for SEISMIC DIAGNOSIS & SELECTION of the ELEMENT

Flow chart for seismic diagnosis	Element of Manual for seismic diagnosis
Primary diagnosis	
1. Data collection for work planning & diagnosis	
2. Site visit	- Visual inspection of structural facilities - Visual inspection of non- structural members of building - Visual inspection of mechanical and electrical equipment
3. Fact Finding Report	
Detail diagnosis	
4. Damage estimations (Feedback)	- Damage estimations for structure by DTSC - Damage estimations for mechanical and electrical equipment by Strength analysis of foundation bolt - Appendix: Japanese aseismic wall-evaluation method for building
5. Structural analysis	- Structural analysis for tanks and building
Earthquake resistant plan	

While carrying out the Seismic Diagnosis, mentioned in the above chart, with our valuable experiences, it is suggested in this manual that some considerations should be made that are listed below.

- Consideration on site survey of structural facilities
- Consideration on site survey of non- structural members of building
- Consideration on site survey of mechanical and electrical equipment
- Consideration on Damage estimations by DTSC for structure

- Consideration on Structural analysis for tank & building
- Consideration on Strength analysis of foundation bolt for mechanical and electrical equipment
- Appendix: Japanese aseismicity evaluation method for building

2. VISUAL INVESTIGATION

2.1 Consideration on visual investigation of structural facilities

2.1.1 Typical Risk Factors/ Key points for site survey

The earthquake-resistance of facility is evaluated with respect to some risks. Before the site survey is undertaken, typical risks and the related key points of inspections shall be decided and confirmed in advance.

(Comment)

The earthquake-resistance of facility is evaluated in terms of some risks, and according to Japan's experience of typical risks, the following fourteen items should be considered as typical risks and related key points for inspections as presented in the Table 2.. These risk factors included in the Japanese diagnostic table has been evaluated statistically. Among these, the most critical risk is the ground conditions. Therefore, if the data on soil/ground conditions cannot be obtained, some inspections on the site complementing the soil conditions should be carried out.

Table-2 TYPICAL RISK FACTORS/ KEY POINTS FOR SITE SURVEY

No.	Risk Factors	Key Point for Survey
1	Ground conditions	Ground conditions have to be inspected and categorized into one of the three categories, i.e., Stiff/ Middle/ Soft. It is an indicator of stability of foundation, and influences the intensity of active earth pressure during earthquakes. Refer to Table-2&3, touching/grasping the soil helps estimation of Soil Consistency
2	Liquefaction	Possibility of liquefaction has to be inspected and evaluated as any of the three categories, i.e., Not occur/ Possible/ Occur. Occurrence depends on the consistency and configuration of soil. It is the indicator of stability of foundation
3	Land features	Land feature has to be inspected and categorized into one of the four categories, i.e., Stiff Cutting/ Sloping/ Top of mountain/ Landfill. It is the indicator of stability of foundation
4	Elevation	Elevation of facility has to be inspected and categorized into one of the three categories, i.e., On the ground/ Semisubterranean/ Underground. It is the indicator of stability of foundation
5	Material	Material of structure has to be inspected and categorized into either

		of the two categories, i.e., RC/ Brick. RC structures are resistant to earthquake
6	RC Wall area	The extent of RC Wall has to be surveyed by visual inspections and through as-built drawing. RC wall are well resistant to the earthquake
7	Water depth	Water depth has to be categorized into two categories, i.e., ＜5m/ ≧5m on the basis of available data. The main points to be concerned about the water pressure during earthquakes are cracks and leakages
8	Structural formation	Structural formation has to be inspected and categorized into one of the three categories, i.e., Wall/ Column & Beam/ Flat slab. Wall structure resistant to earthquake
9	Soil cover	Soil cover on top slab has to be categorized into one of the two categories, i.e., ＜0.4m/ ≧0.4m on the basis of available data.
10	Construction year	Construction year has to be categorized into one of the two categories, i.e., in or after 1995/ before 1995, on the basis of available data, on hearing or manufacturing year mentioned on the equipment. It is assumed that the buildings constructed in or after 1995 are resistant to earthquake in Tehran.
11	Flexible pipe	To be inspected whether flexible pipe is Existing or Not. It influences the probability of water leakage.
12	Expansion Joint (Ex. J.)	To be inspected whether Ex.J. is in good conditions/ Not. It influences the probability of water leakage.
13	Degree of Degradation	Degree of degradation has to be inspected and the degree of degradation has to be categorized into one of the three categories, i.e., Small/ Medium/ Intense. It is the problem of the dependability as structure.
14	Seismic intensity scale	Depends on the location

2.1.2 Inspections of Soil and Concrete

Site survey consists of rough test of soil and strength-of- concrete test other than visual inspection.

1) If soil survey data are not available, rough test of soil should be performed at the exposed cutting soil face.
2) Preparing for structural analysis included in the next detailed diagnosis, whether reduction of design strength is required or not is judged by performing a strength-of-concrete test in the site.

(Comment)

1) When no data on soil is available, soil data can be obtained by easy observation and rough tests for sandy soil and cohesive soil as explained in Tables below.

Table-2 ROUGH DENSITY TEST FOR SANDY SOIL

N value	Relative Density	Rough Density Test
0～4	Very loose	ϕ13mm bar is pierced into the ground easily by hand.
4～10	Loose	It can be excavated with a scoop.
10～30	Medium	ϕ13mm bar can be easily pierced into the ground by a five pound hammer.
30～50	Dense	ϕ13mm bar can be pierced 30cm into the ground by a five pound hammer.
>50	Very dense	ϕ13mm bar can be pierced only 5cm into ground by a five pound hammer. A pecker is required to excavate.

Table-3 ROUGH CONSISTENCY TEST FOR COHESIVE SOIL

N value	Clayey Consistency	Rough test for Consistency
<2	Very soft	A clenched fist enters 10cm into the ground easily.
2～4	Soft	A thumb enters 10cm into the ground easily.
4～8	Medium	A thumb enters 10cm into the ground with effort
8～15	Firm	The ground face is only dented by pressure with a thumb.
15～30	Very firm	It is carved into the ground face by a nail.
>30	Extremely firm as a rock	It is difficult to carve into the ground face by a nail.

.

2) Strength-of- concrete test

- In the case of neutralization not advancing

According to the survey on structures of several Tehran water supply facilities, neutralization of the concrete of water tanks, pump chamber and other concrete structures in the premises were not observed to be advancing. It was concluded that this might be as a result of relatively dry weather, good ventilation and very good watertight concrete, which reduced the water cement ratio. So compressive strength of concrete can be measured by a Schmidt rebound hammer, and might be applied to the design conditions, viz. 300 kg/cm^2 for water tank and 250 kg/cm^2 for building on the ground.

Usually, concrete provides alkalinity (pH 12-13) due to presence of hydroxylated calcium. Therefore, in this alkaline environment in concrete, a protection barrier is formed around a reinforcing bar, and iron is protected from corrosion. The hydroxylated calcium changes to carbonic acid calcium with passage of time through the action of the carbon dioxide in the air, which is called neutralization. Although Carbonic acid calcium present in concrete is hard, it has no protective strength for reinforced iron. Therefore if neutralization advances, the non-destructive test by a Schmidt rebound hammer couldn't be used. Furthermore, if neutralization advances, a protection barrier for iron would no longer be formed around a reinforcing bar and iron corrosion will start.

Neutralization could be measured chemically by using the nature in which the face of alkaline (pH 9-10 or more) concrete changes into purplish red color if phenol-phthalein liquid is sprayed over the concrete.

Picture Phenol-Phthalein Testing on the wall of utility conduit of Pulsator at WTP No.2

- In the case of neutralization advancing

A Schmidt rebound hammer cannot measure compressive strength of neutralized concrete. Therefore concrete core shall be abstracted from designated member, and neutralized portions should be removed, then a compression test should be performed.

2.2 Consideration on site survey of non- structural members of building

2.2.1 General

Fragile and cracked non-structural members will fall down in case of occurrence of an earthquake and will lead to an accident resulting in injury or death. So inspector should investigate in detail around the maintenance way and the room in which people reside for routine work.

(Comment)

The non- structural members of building, such as windowpane, fragile and cracked members and the tile/veneer which is likely to separate resulting from shoddy workmanship or through deteriorations, become potential weapons in case of occurrence of an earthquake, and might fall down and lead to an accident resulting in injury or death.

So inspector should take a photograph and make some sketches in detail of the target building for these elements.

Target buildings for this kind of inspection are as follows:

- the room in which people reside for a routine work
- the building located along maintenance way

2.2.2 Key points for site survey

Risk Factors of diagnosis viz. main components to be considered during site survey are as follows:

- Finishing materials on wall
- Finishing materials/equipment on ceiling
- Flooring material
- Fixtures
- Brick Wall
- Furniture
- Gatepost/Wall Fence

(Comment)

The earthquake-resistance of non-structural members is evaluated in terms of some indicative factors for each element. According to Japan's experience of typical risks, the main Risk factors along with their indicative Key Point for Survey are listed in the following Table.

No	Risk Factors	Key Point for Survey
1	Finishing materials on wall	Fragile, cracked, deteriorated or separated Marble Veneer/Brick finishing /Mortar finishing, which is likely to fall off

2	Finishing materials / Equipment on ceiling	Mortar finishing/lighting equipment, which is likely to fall off
3	Flooring material	Slippery, separated or cracked Tiling, which is likely to fall off
4	Fixtures	-Deteriorated window frame, which result into broken windowpane. - Stuck or Blocked old door and door frame, which prevent people to escape through when the earthquake occurs. - Absence of handrail in Water Tanks, which might result into falling of person into water tank.
5	Brick wall	Deteriorated Brick wall in high position, which is easy to collapse and injure person and damage equipment.
6	Furniture	Not fixed Rack/Shelves, which is likely to topple down.
7	Gatepost/Wall Fence	-Deteriorated Finishing materials on Gatepost/Wall Fence, which is likely to fall off. - Unstable Gatepost/Wall Fence, which is likely to topple down

2.3 Consideration on site survey of mechanical and electrical equipment

2.3.1 Confirmation of items for visual check and aim of inspection

Primary diagnosis should include all the facilities and it should be carried out with simple methods through visual inspection. The items for visual check and aim for inspections should be confirmed in advance.

(Comment)

The items for visual check and aim for inspections are explained in the following Table

No.	Items that require site survey	Reason for Survey
1	Condition of Foundation (pump)	Pump is in danger of overturn or sideslip by earthquake if it is not installed properly. It may cause failure of facility.
2	Condition of Foundation (tank)	Tank is in danger of overturn or sideslip by earthquake if it is not installed properly. It may result into failure of facility.
3	Chlorine Dosing Equipment	Chlorine cylinder is in danger of movement or sideslip by earthquake if it is not fixed and stored properly. The occurrence of earthquake may lead to gas leakage as well as the failure of facility.
4	Installation of Emergency Shut-off Valve	Emergency shut-off valve is necessary for reservoir to prevent secondary disaster and wasting water by leakage.
5	Condition of Foundation (self-standing panel)	Self-standing panel is in danger of overturn or sideslip by earthquake if it is not installed properly. It may cause failure of facility.
6	Condition of Foundation (transformer)	Transformer is in danger of overturn or sideslip by earthquake if it is not installed properly. It may result into fire as well as the failure of the facility.
7	Condition of Foundation (battery)	Battery is in danger of overturn or sideslip by earthquake if it is not installed properly. It may lead to failure of facility.
8	Condition of Foundation (UPS)	UPS (Uninterruptible Power Supply) is in danger of overturn or sideslip by earthquake if it is not installed properly. It may cause failure of facility.
9	Piping and Cabling Work around the Expansion Joint	The earthquake could generate displacement at expansion joint because the movements of structures are different from each other. That may cause damage to cables & pipes.
10	Spare Length of Cable	Enough spare length of cable is necessary to prevent damage to cable.

11	Installation of Emergency Generator	Emergency generator is necessary for reservoirs with pumping station as well as WTP to ensure power source during power supply failure.
12	Construction of Anti-flow out Fence	Construction of anti-flow out fence under the oil tank is necessary to prevent secondary disaster.
13	Electric Post	Electric post needs to be installed properly to prevent from toppling.
14	Duplicate Incoming Cable	It is desirable to provide duplicate incoming cable for large scale and important facility.
15	Installation of Standby Pump	Even though one of the pumps has damaged, standby pump can prevent failure of facility.
16	Installation of Flexible Pipe Between Fuel Tank and Generator	If flexible pipe is not installed, earthquake could damage the pipe and cause fuel leakage.

2.3.2 Survey of foundation bolt

For calculation in next phase, further data is needed including as-built drawing of each equipment, shape of foundation bolt, etc. It is better to collect the information on the shape and diameter of foundation bolt from the site, especially in the cases where those data do not exist on drawings.

(Comment)

In addition to the shape and diameter of foundation bolt, following information is required for calculation:

- distance between installation level and center of gravity
- distance between anchor bolt and center of gravity
- distance between anchor bolts
- weight of equipment
- output of motor
- speed of motor
- thickness of foundation concrete

- **3. DAMAGE ESTIMATIONS**

3.1 Damage estimations by DTSC for structure

3.1.1 Policy for the introduction of DTSC

As the method of Japanese Diagnostic Table for Seismic Capacity (hereafter referred to as DTSC) is the most objective evaluation method for assessment of damage, it shall be adopted to estimate damages of structural facilities in Tehran water supply system.

(Comment)

DTSC is the method to evaluate fourteen risk factors in terms of their fragility point.

The table for reservoir and non-slab water tank was prepared by Japan Health and Welfare Ministry in 1981, and the fragility point has been modified in 2005 based on the latest earthquake damage statistics in Japan by Japan Water Research Center under a subsidy of Health, Labor and Welfare Ministry. (DTSC for Pumping Stations and Administration buildings have not been prepared)

3.1.2 Some modifications of DTSC

Three modifications to the scope of Japanese DTSC should be made in order to make it applicable to the conditions in Tehran. These modifications include

1) Modification on construction year
2) Modification on earthquake resistant wall for Pump House
3) Modification of DTSC for top-slabless tank

(Comment)

1) Modification on construction year

Code 2800 was issued in 1987, and a duty of application went into effect legally after Roodbar-Manjil earthquake in 1990, and considering 5 years of time lag for design and construction, we assume that the buildings completed after 1995 have high seismic capacity.

Table-4 MODIFICATION ON CONSTRUCTION YEAR

Japanese DTSC			Modified DTSC for Iran	
Scope	Fragility point		Scope	Fragility point
from 1975 onward	1.0	⇒	from 1995 onward	1.0
1926≦ ≦1974	1.2			
before 1925	1.5		before 1995	1.5

2) Modification on earthquake resistant wall for Pump House

Regarding the evaluation on earthquake resistant wall for Reservoir, there are two categories of wall area in the original DTSC.

Table-5 ORIGINAL EVALUATION OF SEISMIC CAPACITY
ON EARTHQUAKE RESISTANT WALL FOR RESERVOIR

Risk Factor	Scope	Fragility Point
Wall area of X-axis and Y-axis ／tank area	＞0.05	1.0
	＜0.05	1.5

Earthquake resistant wall of Pump house has a central role in evaluation for seismic capacity. So the scope and fragility point on earthquake resistant wall, viz. evaluation of Wall area was modified based on Reservoir's DTSC and verified by structural analysis of pump house.

Table-6 EVALUATION OF SEISMIC CAPACITY
ON EARTHQUAKE RESISTANT WALL FOR PUMP HOUSE
(modified based on Reservoir's DTSC)

Risk Factor	Scope	Fragility Point
Wall area of X-axis and Y-axis ／tank area	＞0.05	1.0
	＜0.05	1.5
	＜0.02	3.0

3) Modification of DTSC for top-slabless tank

Regarding Japanese DTSC for top-slabless tank, degree of degradation and water depth are not considered as risk factors. Especially in Teheran, Pulsator's top-slab does not exist. In the cases of Structures with greater height or depth, water depth shall be considered in DTSC as presented in structural analysis of WTP No.2 Pulsator. Also, there are so many tanks and the degree of degradation are varying in these cases therefore, DTSC should be modified for degradation levels based on DTSC for the Reservoir.

3.1.3 Proposed DTSC

There are three proposed DTSCs for Reservoir, Pump house and Treatment Tank.

Table-7 DTSC FOR RESERVOIR (applicable for the structure with slab)

Risk Factor	Scope	Fragility Point
Ground	Type-1	0.5
	Type-2	1.0

	Type-3	1.8
Liquefaction	Not occur	1.0
	Possible	2.0
	Occur	3.0
Land features	Cutting ground	1.0
	Sloping ground	1.2
	Top of mountain	1.3
	Landfill	1.5
Elevation	On the ground	1.2
	Semisubterranean	1.1
	Underground	1.0
Material	RC	1.0
	Brick	3.0
Wall area of X-axis and Y-axis ／tank area	＞0.05	1.0
	＜0.05	1.5
Water depth	＜5m	1.0
	≧5m	1.3
Structural formation	Wall	1.0
	Column & Beam	1.2
	Flat slab	1.4
Soil cover	＜0.4m	1.0
	≧0.4m	1.2
Construction year	From 1995 onward	1.0
		1.2
	Before 1995	1.5
Flexible pipe	Existing	1.0
	Absent	2.0
Ex.j	Good condition	1.0
	Bad condition	2.0
Degree of Degradation	Small	1.0
	Medium	1.5
	Intense	2.0
Seismic intensity scale	5 (approx.100～250gals)	1.0
	6 (approx.250～800gals)	2.2
	7 (approx. over 800gals)	3.6
Aseismicity	high-level	<10

	middle-level	10～17
	low-level	>17

Table-8 DTSC FOR PUMP HOUSE

Risk Factor	Scope	Fragility Point
Ground	Type-1	0.5
	Type-2	1.0
	Type-3	1.8
Liquefaction	Not occur	1.0
	Possible	2.0
	Occur	3.0
Land features	Cutting ground	1.0
	Sloping ground	1.2
	Top of mountain	1.3
	Landfill	1.5
Elevation	On the ground	1.2
	Semisubterranean	1.1
	Underground	1.0
Material	RC	1.0
	Brick	3.0
Wall area of X-axis and Y-axis ／tank area	＞0.05	1.0
	＜0.05	1.5
	＜0.02	3.0
Water depth	＜5m	1.0
	≧5m	1.3
Structural formation	Wall	1.0
	Column & Beam	1.2
	Flat slab	1.4
Soil cover	＜0.4m	1.0
	≧0.4m	1.2
Construction year	From 1995 onward	1.0
		1.2
	Before 1995	1.5
Flexible pipe	Existing	1.0
	Absent	2.0

Ex.j	Good condition	1.0
	Bad condition	2.0
Degree of Degradation	Small	1.0
	Medium	1.5
	Intense	2.0
Seismic intensity scale	5 (approx.100～250gals)	1.0
	6 (approx.250～800gals)	2.2
	7 (approx. over 800gals)	3.6
Aseismicity	High-level	＜10
	Middle-level	10～17
	Low-level	＞17

Table-9 DTSC FOR WATER TANK (applicable for structure with non-top-slab)

Risk Factor	Scope	Fragility Point
Ground	Type-1	0.6
	Type-2	1.0
	Type-3	2.0
Liquefaction	Not occur	0.6
	Possible	1.0
	Occur	2.0
Land features	Cutting ground	1.0
	Sloping ground	1.2
	Top of mountain	1.3
	Landfill	1.5
Elevation	On the ground	1.2
	Semisubterranean	1.1
	Underground	1.0
Material	RC	1.0
	Brick	3.0
Wall area of X-axis and Y-axis／tank area	＞0.2	1.0
	0.2～0.12	1.2
	＜0.12	1.5
Water depth	＜5m	1.0
	≧5m	3.0

Construction year	From 1995 onward	1.0
		1.5
	Before 1994	1.8
Flexible pipe	Existing	1.0
	Absent	1.8
Ex.j	Good condition	1.0
	Bad condition	2.0
Degree of Degradation	Small	1.0
	Medium	1.5
	Intense	2.0
Seismic intensity scale	5 (approx.100～250gals)	1.0
	6 (approx.250～800gals)	2.2
	7 (approx. over 800gals)	3.6
Aseismicity	High-level	＜10
	Middle-level	10～30
	Low-level	＞30

3.1.4 Procedure for calculation of total fragility point Multiplication of fragility point on each risk factors provides the value of Total Fragility of structure.

(Comment)

Procedure for calculation of total fragility point is as follows.

1) The fragility point, corresponding to each scope of risk factor, is selected
2) Selected fragility points are mutually multiplied.
3) Seismic capacity is evaluated from the definition of seismic capacity viz. the relation between total fragility point and a seismic capacity level.

Calculation of total fragility point
(typical case of Reservoir in Tehran)

Seismic intensity	Total fragility point
5:(approx.100～250gals)	0.5*1.0*1.0******1.0=3.8
6:(approx.250～800gals)	0.5*1.0*1.0******2.2=8.3
7:(approx. over 800gals)	0.5*1.0*1.0******3.6=13.6

Definition of Seismic capacity

Total fragility point	Seismic resistance capacity
＜10	High-level
10～17	Middle-level
＞17	Low-level

3.2 Consideration on Structural analysis for tank and building

3.2.1 Selection of Code

As the seismic design for tank with life-time 50-years, is based on Code-2800 with a 100-year earthquake return period, seismic diagnosis should also be carried out according to Code-2800.

(Comment)

Level 2 of design, which means the most crucial condition in Japan, considering a 100-year return of rare earthquakes that exceeds the life-time (50-years) of the structure, is generally practiced in Iran. The criteria aim at protection of a) human life, and b) the maintenance and provision of minimum services. Acceleration 0.35g on Code 2800 has a 100-year occurrence probability, same probability as of Japanese Level 2, and the analysis is carried out in the elastic range of material. In doing so, design criteria have enough allowances for the structural design with life-time of 50-years. Therefore, Code-2800 is applied while carrying out seismic diagnosis.

It is important that the outcome of damage estimation using several scenario earthquakes is considered in order to find the order of priority in execution of reinforcement. For instance in the earthquake analysis of North Tehran Fault of possibly several centuries earthquake occurrence probability, it is noted that acceleration is 0.691g on Reservoir No.23, so this structure’s reinforcement is of high priority, and should be designed based on Code 2800.

3.2.2 Necessity of Soil Survey

Structural analysis should be carried out on the basis of the existing soil conditions. The data on soil conditions should be collected through drilling survey at the location of target structure.

(Comment)

Based on the soil conditions, result of seismic diagnosis will be changing to a great extent, such as countermeasure for tank is required, or is not needed at all. For example Reservoirs that were constructed 50 years ago might not have sufficient reinforced bars. In the original design, in normal case, earth pressure was not forced to wall, so area of reinforced bar was small. As the ground is firm, that kind of design is possible. However, the soil survey report or design sheet does not exist, therefore, the designer could not judge properly. Friction angle for sandy gravel varies from a minimum of 40 degrees to maximum of 50 degree. In this study, to be on the safe side, study team hes selected 40 degrees and proposed countermeasures accordingly. However, if soil survey is performed, the results might indicate that the countermeasures are not required. Therefore, soil survey of existing ground and soil conditions is necessary for structural analysis.

3.2.3 Priority for Structural Analysis

When there are many target structures, the following structures should be considered to have high priority for required structural analysis:

1) The deep tank with no slab
2) Long span, high building or facilities with special structural formations'
3) The building in which people reside continuously or during working hours

(Comment)

1) The deep tank with no slab

Generally speaking, a tank has high seismic capacity due to wall structure. Therefore shallow tank has enough strength against earthquake and priority of structural analysis study in this case is low.

On the other hand, deep tank, for instance Pulsator with over 5 m depth is not known in Japan, so damage estimation by Japanese DTSC is impossible specifically. Therefore, structural analysis should be carried out at the beginning.

In addition, on the structure with high priority of study, countermeasure should be formulated and implemented in future. Therefore, at the time of the soil survey, needed space for construction or other required conditions for implementation of countermeasure should be surveyed.

2) Long span, high building or facilities with special structural formations'

Buildings with large load and a structure in which an eccentric load is generated should be studied preferentially for structural analysis.

3) The building in which people reside continuously or during working hours

As the criteria for earthquake resistant plan aims at protection of human life which is more important than anything else, the building in which people reside permanently or during working hours should be preferably studied for structural analysis.

3.3 Consideration on Strength analysis of foundation bolt for mechanical and electrical equipment

3.3.1 Purpose of analysis

Strength Analysis of the foundation bolt should be carried out to confirm whether the equipment has stability against earthquake or not.

(Comment)

Strength of the foundation bolt should not be observed only by visual survey, but also main equipment should be analyzed for Strength of the foundation bolt.

3.3.2 Method of analysis

There is no Iranian code for the method of strength analysis of foundation bolt, so Japanese code should be referred for seismic resistant design in the document titled "Seismic Design & Construction Guidelines for Building equipment (1997)" by the Building Center of Japan.

(Comment)

- The seismic force which exerts force on the equipment is analyzed in two directions i.e., horizontal and vertical. The exerted seismic force in these directions is calculated using following equations:

Horizontal seismic force

$$FH = KH \cdot W \cdot 9.8 \text{ [N]}$$

Vertical seismic force

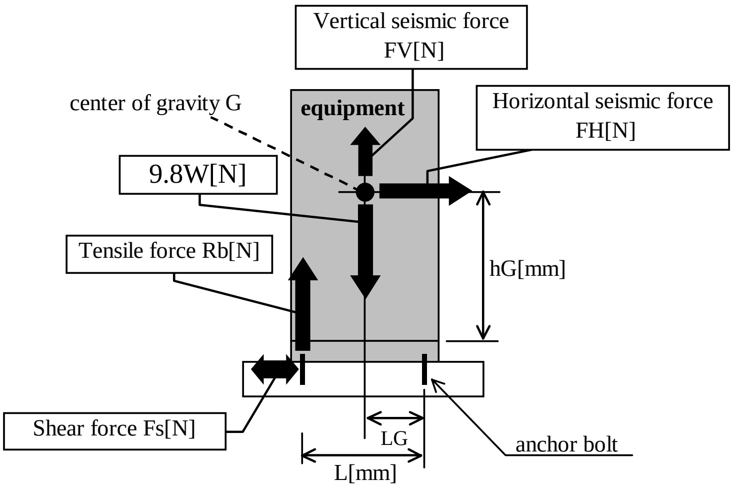
$$FV = (1/2) \cdot FH \text{ [N]}$$

Here, KH : horizontal seismic factor

If equipment is installed at basement or ground floor, KH=0.6

W : weight of equipment [kg]

In general, equipment is fixed with the structure using anchor bolts. When earthquake occurs, tensile force and shear force acts on the anchor bolts. Following figure illustrates how the tensile force and the shear force work.



Here,	hG[mm] :	distance between installation level and center of gravity
	LG[mm] :	distance between anchor bolt and center of gravity
	L[mm] :	distance between anchor bolts
	W[kg] :	weight of equipment

Following two equations must be satisfied to prevent the equipment from overturning or sideslipping by seismic force.

Allowable tensile force of anchor bolt > Tensile force on anchor bolt by seismic force
Allowable shear force of anchor bolt> Shear force on anchor bolt by seismic force

APPENDIX: JAPANESE SEISMIC WALL-EVALUATION METHOD FOR BUILDING

On the introduction of Japanese seismic wall-evaluation method for building

Buildings in Japan have high earthquake resistance, if the foundation is good. This is because, in general, RC wall has been adopted as outer and inner wall.

Therefore, Japanese wall evaluation method for seismic diagnosis was developed, which is applied to building with RC wall.

This method is introduced here and could be considered usefulness for the case of Iran also.

JAPANESE SEISMIC WALL-EVALUATION METHOD FOR BUILDING

Regarding the Japanese Wall-Evaluation Method, only the horizontal area of columns &walls of building is calculated, and the seismic horizontal resistance of the structure could be evaluated using following equation.

$$Qu = \Sigma 25 Aw + \Sigma 7 Ac \geqq Qun = C0 \cdot I \cdot 1/U \cdot Wi \qquad \text{——} \qquad (1)$$

Qu : the seismic horizontal resistance of the building

Qun : the seismic horizontal shear of the building

Wi : the weight of the each stories of the building

Aw : the horizontal sectional area of parallel walls to the direction.

Ac : the horizontal sectional area of columns

C0 : the standard shear coefficient(C0=1.0 for the level Ⅱ)

I : Importance factor of the building

U : the deterioration factor of the building

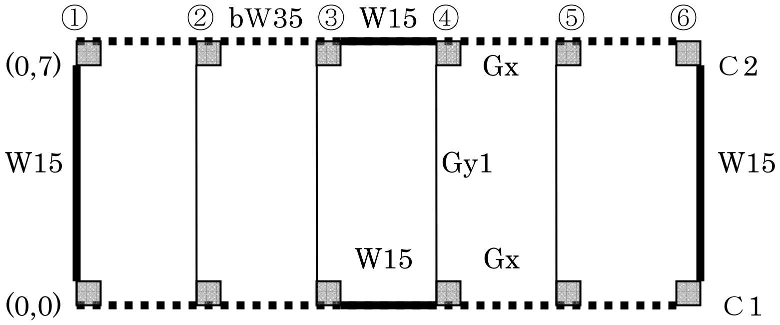
(U=1.0 from 1995 onward、U=0.9 before 1995)

The Example to be applied Japanese Wall-Evaluation Method to Pump house No.2

The example which is applied Japanese Evaluation Method to Pump house No.2, is calculated as follows.

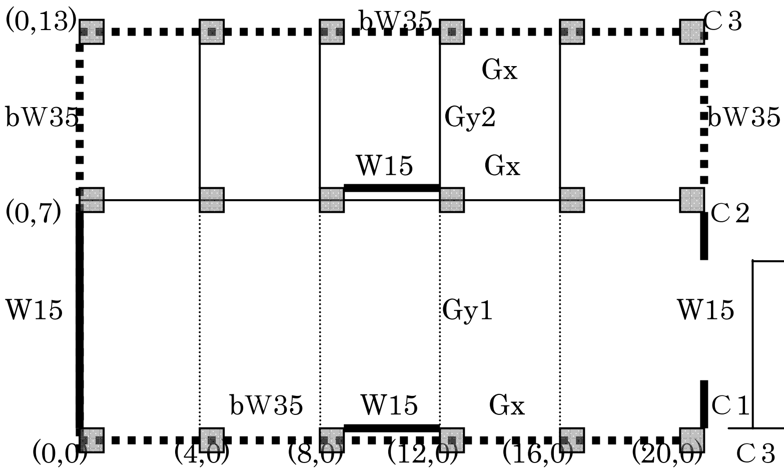
1. Assumption of the arrangement of share wall

Share walls are arranged each two for X and Y direction, totally four walls for each floor.

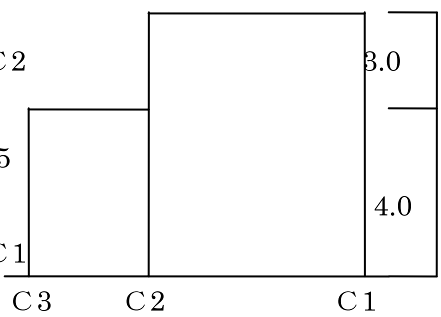


1-st Floor Plan

Note. W15 means 15 cm of wall thickness.



Ground Floor Plan



Section

2. Basic condition of section and load of columns &walls（unit：cm）

①column：C1（40×50）、C2（40×50）、C3（40×40）

②wall　　：W15

③brick wall：bW35

④roof slab　：S15

⑤girder　：Gx（35×50）、Gy（35×60）

⑥hight of 1-st floor story　　：300

⑦hight of ground floor story：400

⑨weight of slab : S15＝2.4×15×100×100／1000 ＝ 360 (kg/m²)

⑩weight of column : C1＝2.4×40×50×100／1000 ＝ 480 (kg/m)

C2＝2.4×40×50×100／1000 ＝ 480 (kg/m)

C3＝2.4×40×40×100／1000 ＝ 390 (kg/m)

⑪weight of girder : Gy1＝2.4×35×(60-15)×650／1000＝2,260 (kg/piece)

Gy2＝2.4×35×(60-15)×555／1000＝2,100 (kg/piece)

Gx＝2.4×35×(50-15)×360／1000 ＝1,060 (kg/piece)

⑫weight of wall : W15＝2.4×15×100×100／1000 ＝ 360 (kg/m²)

bW35＝1.8×35×100×100／1000 ＝ 630 (kg/m²)

⑬live load on roof : L.L＝ 100 (kg/m²)

⑭the deterioration factor of the building U ＝ 0.9（before 1995）

2. First trial

2.1 The condition for seismic evaluation of columns &walls

The condition for seismic evaluation, horizontal sectional area, seismic strength, the weigh, and the horizontal force of columns &walls are calculated by step 1 through step 4.

Step 1

The calculation of the horizontal sectional area of columns on the each floor

C1＝C2＝40×50＝2,000 (cm^2)

C3＝ 40×40＝1,600 (cm^2)

1-st floor ΣAc＝6×（C1＋C2） ＝6×（2,000＋2,000） ＝24,000(cm^2)

Ground floor ΣAc＝6×（C1＋C2＋C3）＝6×（2,000＋2,000＋1,600）＝33,600(cm^2)

Step 2

The calculation of the horizontal sectional area of walls on the each floor

1-st floor ΣAwx＝ 2×15×360 ＝10,800(cm^2)

ΣAwy＝ 2×15×650 ＝19,500(cm^2)

Ground floor ΣAwx＝ 2×15×360 ＝10,800(cm^2)

ΣAwy＝15×(650＋2×175)＝15,000(cm^2)

Step 3

The calculation of the seismic strength of the building by the columns &walls on the each floor, in each direction.

1-st floor X-direction Qx＝25×ΣAwx＋7×ΣAc

＝25×10,800＋7×24,000＝270,000＋168,000＝438,000kg

Y-direction Qy＝25×ΣAwy＋7×ΣAc

＝25×19,500＋7×24,000＝487,500＋168,000＝655,500kg

Ground floor　X-direction Qx＝25×ΣAwx＋7×ΣAc

＝25×10,800＋7×33,600＝270,000＋235,200＝505,200kg

Y-direction Qy＝25×ΣAwy＋7×ΣAc

＝25×15,000＋7×33,600＝375,000＋235,200＝610,200kg

Step 4

The calculation of the weigh and the horizontal force of the earthquake of the each floor of the building

4-1) Weigh of the 1-st floor of the building.

Slab　W1＝(360＋100)×20.4×7.5＝　70,380kg

Column　W2＝6×C1×h＋6×C2×h　＝6×(480+480)　×4.0＝23,040kg

Girder　W3＝6×Gy1＋　2×5×Gx

＝6×2,260　＋ 10×1,060＝13,560＋10,600　＝24,160kg

wall(W15) W4＝2×360×(6.5×2.4 ＋3.60×2.5)

＝2×360×(15.6 ＋ 9.0)　＝ 17,720kg

wall(bW35)　W5＝630×2×（6.5×2.40＋4×3.60×2.50)

＝630×2×（15.6＋36.0) ＝630×2×51.6　＝　65,020kg

■　ΣW_{1F}＝W1＋W2＋W3＋W4＋W5

＝70,380＋23,040＋24,160＋17,720＋65,020 ＝ 200,320kg

4-2) Horizontal force of the earthquake on the 1-st floor.

Qun_{1F}＝C0・I・1/U・Wi＝1.0×1.2×1/0.9×200,320

＝267,100kg

4-3) Weigh of the ground floor of the building.

Slab　W1＝(360＋100)×20.4×6.2＝　58,180kg

Column　W2＝6×h×(C1＋C2＋C3)＝6×4.0×(480+480+390)＝32,400kg

Girder　W3＝2×Gy1＋6×Gy2＋3×5×Gx

＝2×2,260＋6×2,100＋15×1,060＝4,520＋12,600＋15,900

＝33,020kg

wall(W15) W4＝2×360×(6.50×3.40＋3.60×3.50) －360×3.0×3.40

＝2×360×(18.7＋12.6)－3,670＝24,990－3,670＝ 21,320kg

wall(bW35)W5＝630×｛2×5.55×3.40＋(4＋5)×3.60×3.50｝

＝630×（37.74＋113.40)　＝　95,220kg

■　ΣW_{GF}＝W1+W2+W3+W4+W5

＝58,180＋32,400＋33,020＋21,320＋95,220＝240,140kg

4-4) Horizontal force of the earthquake on the ground floor.

Qun_{GF}＝C0・I・1/U・Wi＝1.0×1.2×1/0.9×（ΣW_{1F}＋ΣW_{GF}）

＝1.0×1.2×1/0.9×（200,320＋240,140）　＝587,280kg

2.2 Evaluation of aseismicity

Evaluation of aseismicity by the equation(1) according to the horizontal area of columns &walls is carried out as follows.

1-st floor $Qun_{1F} = 267{,}100kg$

X-direction $Qx = 25 \times \Sigma Awx + 7 \times \Sigma Ac = 438{,}000kg$

$\therefore \quad Qx = 438{,}000kg \geqq Qun_{1F} = 267{,}100kg$ ——— O. K

Y-direction $Qy = 25 \times \Sigma Awy + 7 \times \Sigma Ac = 655{,}500kg$

$\therefore \quad Qy = 655{,}500kg \geqq Qun_{1F} = 267{,}100kg$ ——— O. K

Ground floor $Qun_{GF} = 587{,}280kg$

X-direction $Qx = 25 \times \Sigma Awx + 7 \times \Sigma Ac = 505{,}200kg$

$\therefore \quad Qx = 505{,}200kg \leqq Qun_{1F} = 587{,}280kg$ ——— N. G

Y-direction $Qy = 25 \times \Sigma Awy + 7 \times \Sigma Ac = 610{,}200kg$

$\therefore \quad Qy = 610{,}200kg \geqq Qun_{1F} = 587{,}280kg$ ——— O. K

Since the area of the X-direction wall at Ground floor was not sufficient, re- arrangement of the thickness of the X-direction wall was required.

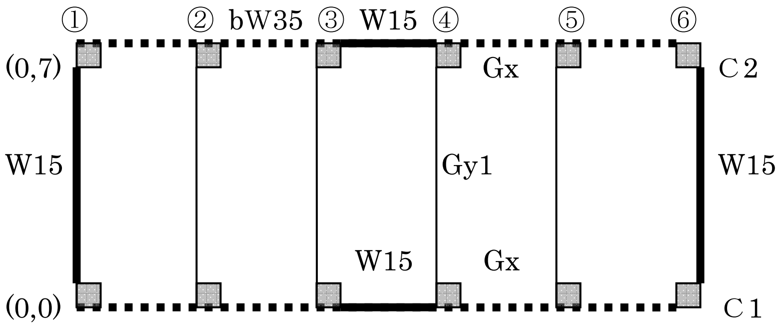
Further study is as follows.

3. Second trial

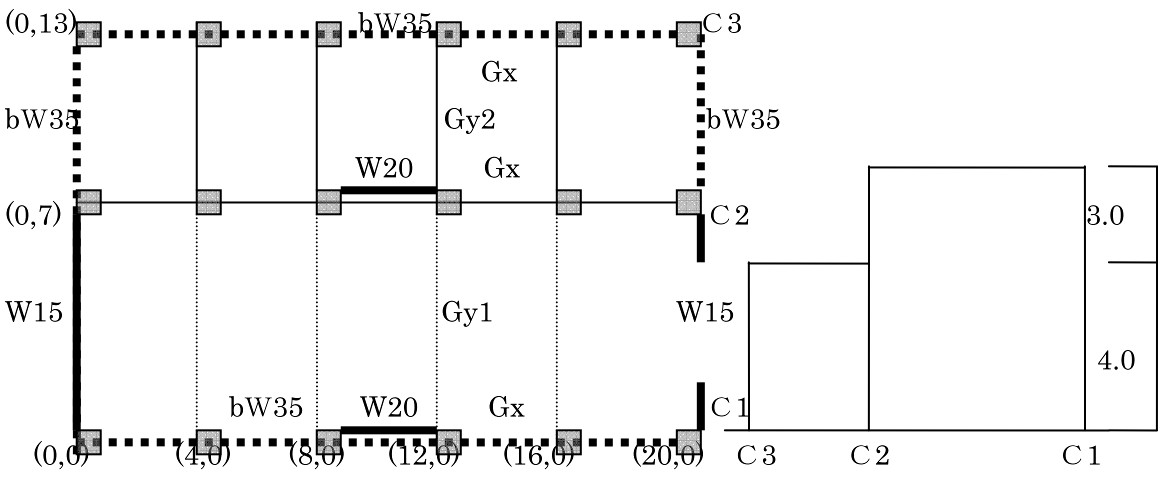
Thickness of the X-direction wall is changed from 15cm to 20cm on the ground floor.
And aseismicity is re-evaluated by step 1 through step 4 as follows.

step 1:The calculation of the horizontal sectional area of each direction walls on the ground floor.

Ground floor $\Sigma Awx = 2 \times 20 \times 360 = 14{,}400(cm^2)$
$\Sigma Awy = 15 \times (650 + 2 \times 175) = 15{,}000(cm^2)$



1-st Floor Plan



Ground Floor Plan Section

step 2:The calculation of the seismic strength of the building by the area of the columns &walls on the ground floor, in each direction.

Ground floor X direction $Qx = 25 \times \Sigma Awx + 7 \times \Sigma Ac$
$= 25 \times 14{,}400 + 7 \times 33{,}600 = 360{,}000 + 235{,}200 = 595{,}200kg$
Y direction $Qy = 25 \times \Sigma Awy + 7 \times \Sigma Ac$

＝25×15,000＋7×33,600＝375,000＋235,200＝610,200kg

step 3:The calculation of the weigh and the horizontal force of the earthquake of the each floor of the building

1-st floor Qun_{1F}＝C0・ I ・1/U・W i ＝1.0×1.2×1/0.9×200,320

＝267,100kg

ground floor Slab W1＝(360＋100)×20.4×6.2＝ 58,180kg

Column W2＝6×h×(C1＋C2＋C3)＝6×4.0×(480+480+390)＝32,400kg

Girder W3＝2×Gy1＋6×Gy2＋3×5×Gx

＝2×2,260＋6×2,100＋15×1,060＝4,520＋12,600＋15,900

＝33,020kg

wall(W15) W4＝360×(2×6.50－3.0) ×3.40 ＝ 12,240kg

wall(W20) =2.4×20×100×100／1000 =480(kg/ m^2)

W4'＝2×480×3.60×3.50 ＝ 12,100kg

wall(bW35)W5＝630×｛2×5.55×3.40＋(4＋5)×3.60×3.50｝

＝630×（37.74＋113.40) ＝ 95,220kg

- ΣW$_{GF}$＝W1+W2+W3+W4+W4'+W5

＝58,180＋32,400＋33,020＋12,240＋12,100＋95,220

＝243,160kg

Therefore Qun_{GF}＝C0・ I ・1/U・W i ＝1.0×1.2×1/0.9×（ΣW$_{1F}$＋ΣW$_{GF}$）

＝1.0×1.2×1/0.9×（200,320＋243,160）

＝591,310kg

step 4 :Evaluation of aseismicity

Evaluation of aseismicity by the equation(1) according to the horizontal area of columns &walls is carried out as follows.

Ground floor Qun_{GF}＝591,310kg

X direction Qx＝25×ΣAwx＋7×ΣAc＝595,200kg

∴ Qx＝595,200kg≧Qun_{1F}＝591,310kg ———— O. K

Y direction Qy＝25×ΣAwy＋7×ΣAc＝610,200kg

∴ Qy＝610,200kg ≧Qun_{1F}＝591,310kg ———— O. K

Since the earthquake resistance of Pump House No.2 was secured with thickness 20cm of the X-direction share wall, calculation would be finished.

APPENDIX-8

Data on Hydraulic Analysis

Appendix 8.1 Deta of Water Supply Facilities

Appendix 8.2 Transmission Network Model

Appendix 8.3 Output of Hydraulic Analysis

APPENDIX-8

Data on Hydraulic Analysis

Appendix 8-1

Deta of Water Supply Facilities

Table 1: Wells

Table 2: Well Pumps

Table 3: Transmission Pumps

Table 4: Distribution Reservoirs

Wells

No.	Name of Well Colony	To	Production (m3/day)	Production (Liter/sec)	Water Level (+m)	Status
No.802-1	Yaftabad	Contact Tank No.73	86,180	997	1,018.00	
No.802-2	Yaftabad	Contact Tank No.73	113,920	1319	1,014.00	
No.803	Ferdows	Reservoir No.69	13,200	153	1,020.00	
No.804	Shahrak Valiasr	Reservoir No.68	8,400	97	1,021.00	
No.805	Shariati	Contact Tank No.66	24,000	278	938.00	
No.806	Khaniabad	Reservoir No.65	12,960	150	946.00	
No.807	Qale Morqi	Reservoir No.89	13,920	161	975.80	
No.808	Moshirieh	Reservoir No.36	32,640	378	1,027.00	
No.809	Reservoir No.16	Reservoir No.16	35,520	411	1,043.00	
No.810	Esfahanak	Contact Tank No.52	146,250	1693	1,031.00	
No.811	Mehrabad	Reservoir No.15	48,570	562	983.00	
No.812	Qolgoli No.3	Reservoir No.13	15,840	183	1,069.00	
No.813	Southern Tarasht	Reservoir No.96	59,100	684	1,039.00	
No.814	Reservoir No.3	Reservoir No.3	73,510	851	1,109.00	
No.815	Reservoir No.4	Reservoir No.4	21,120	244	1,124.00	
No.816	Reservoir No.5	Reservoir No.5	22,800	264	1,099.00	
No.817	Reservoir No.6	Reservoir No.6	0	0	1,239.00	Not Used
No.818	Eigehi	Reservoir No.31	13,200	153	1,093.00	
No.819	Qasr-e-Firouzeh	Transmission Netwwork	0	0	1,079.00	Not used
No.820	Resalt (Tehranpars)	Reservoir No.7	33,288	385	1,127.00	
No.821	Resalt (Araqi)	Reservoir No.7	36,062	417	1,127.00	
No.822	Reservoir No.2	Reservoir No.2	9,600	111	1,201.00	
No.823	Jalalieh	WTP-1	34,560	400	1,115.00	
No.824	Qolgoli No.1	Raw Water Conduit (from Deep Wells)	7,920	92	1,125.00	
No.825	2nd group Kan	Contact Tank No.191 (WTP-2)	42,240	489	1,160.00	
No.826	Shahrak Sadr	Elevated Tank No.109	0	0	1,540.00	Not Used
No.827	Maqsoudbeyk	Reservoir No.22	0	0	1,402.00	Not Used
No.828	Reservoir No.21	Reservoir No.21	12,000	139	1,391.00	
No.830	Reservoir No.41	Reservoir No.41	0	0	1,402.00	Not Used
No.831	Aqdasieh	Reservoir No.40	27,000	313	1,351.00	
No.832	Ozgol	Reservoir No.19 = No.42	16,800	194	1,267.00	
No.833	Reservoir No.11	Reservoir No.11	5,670	66	1,179.00	
No.891	Neserieh	Raw Water Conduit (from Deep Wells)	5,040	58	1,107.00	
No.892	Qolgoli No.2	WTP-1	58,202	674	1,118.00	
		Total (encluding canceled wells)	1,029,512			

Well Pumps

No.	from	to	Pump Capacity (m3/day)	Amount of Flow (m3/hr)	Flow (Liter/sec)	Head (m)	Elevation (+m)	Status
No.802-1	Yaftabad	Contact Tank No.73	86,180	3,591	998	170	994.00	
No.802-2	Yaftabad	Contact Tank No.73	113,920	4,747	1,319	200	964.00	
No.803	Ferdows	Reservoir No.69	13,200	550	153	200	956.00	
No.804	Shahrak Valiasr	Reservoir No.68	8,400	350	97	120	1,016.00	
No.805	Shariati	Contact Tank No.66	24,000	1,000	278	190	933.00	
No.806	Khaniabad	Reservoir No.65	12,960	540	150	170	946.00	
No.807	Qale Morqi	Reservoir No.89	13,920	580	161	150	958.00	
No.808	Moshirieh	Reservoir No.36	32,640	1,360	378	130	1,017.00	
No.809	Reservoir No.16	Reservoir No.16	35,520	1,480	411	180	995.00	
No.810	Esfahanak	Contact Tank No.52	146,250	6,094	1,693	180	985.00	
No.811	Mehrabad	Reservoir No.15	48,570	2,024	562	200	978.00	
No.812	Qolgoli No.3	Reservoir No.13	15,840	660	183	190	1,065.00	
No.813	Southern Tarasht	Reservoir No.96	59,100	2,463	684	200	1,034.00	
No.814	Reservoir No.3	Reservoir No.3	73,510	3,063	851	180	1,071.00	
No.815	Reservoir No.4	Reservoir No.4	21,120	880	244	170	1,081.00	
No.816	Reservoir No.5	Reservoir No.5	22,800	950	264	180	1,077.00	
No.817	Reservoir No.6	Reservoir No.6	0	0	0	150	1,104.00	Not used
No.818	Eigehi	Reservoir No.31	13,200	550	153	170	1,089.00	
No.819	Qasr-e-Firouzeh	Transmission Netwwork	0	0	0	180	1,071.00	Not used
No.820	Resalt (Tehranpars)	Reservoir No.7	33,288	1,387	385	200	1,121.00	
No.821	Resalt (Araqi)	Reservoir No.7	36,062	1,503	418	200	1,121.00	
No.822	Reservoir No.2	Reservoir No.2	9,600	400	111	120	1,197.00	
No.823	Jalalieh	WTP-1	34,560	1,440	400	180	1,082.00	
No.824	Qolgoli No.1	Raw Water Conduit (from Deep Wells)	7,920	330	92	140	1,120.30	
No.825	2nd group Kan	Contact Tank No.191 (WTP-2)	42,240	1,760	489	210	1,148.00	
No.826	Shahrak Sadr	Elevated Tank No.109	0	0	0	160	1,536.00	Not used
No.827	Maqsoudbeyk	Reservoir No.22	0	0	0	140	1,393.00	Not used
No.828	Reservoir No.21	Reservoir No.21	12,000	500	139	150	1,388.00	
No.830	Reservoir No.41	Reservoir No.41	0	0	0	200	1,396.00	Not used
No.831	Aqdasieh	Reservoir No.40	27,000	1,125	313	200	1,346.00	
No.832	Ozgol	Reservoir No.19 = No.42	16,800	700	194	200	1,264.00	
No.833	Reservoir No.11	Reservoir No.11	5,670	236	66	210	1,171.00	
No.891	Neserieh	Raw Water Conduit (from Deep Wells)	5,040	210	58	170	1,099.80	
No.892	Qolgoli No.2	WTP-1	58,202	2,425	674	150	1,113.50	To be confirmed
		Total (encluding canceled wells)	1,029,512					

Pumps

No.	from	to	Pump Capacity (m3/hr)		Number of Installed Pump		Number of Working Pump		Working Hour		Head (m)	Elevation (+m)	Amount of Flow (m3/day)	Flow (Liter/sec)	Status
No.001-1	Distribution Reservoir No.1	Distribution Reservoir No.9	1,600	1,000	2	1	2	0	24	0	141		76,800	889	
No.001-2	Distribution Reservoir No.1	Distribution Reservoir No.14	1,360	900	3	2	2	0	20	0	141		54,400	630	
No.001-3	Distribution Reservoir No.1	Distribution Reservoir No.61									141		0	0	Not used
No.002	Distribution Reservoir No.2	Distribution Reservoir No.10	1,370	1,300	2	2	0	2	0	19	52		49,400	572	
No.008	Distribution Reservoir No.8	Distribution Reservoir No.18	500	330	2	1	1	1	0	6	110		1,980	23	
No.013	Distribution Reservoir No.13	Concrete Pipeline	800	500	6	6	2	3	21	18	90.3		60,600	701	
No.14-1	Distribution Reservoir No.14	Distribution Reservoir No.22	1,600		3		2		8		78		25,600	296	
No.14-2	Distribution Reservoir No.14	Jordan Pipeline	840		3		2		24		78		40,320	467	
No.015	Distribution Reservoir No.15	Distribution Reservoir No.13	1,400		4		2		23		76		64,400	745	
No.016	Distribution Reservoir No.16	Distribution Reservoir No.51	1,800		4		1		6		76		10,800	125	
No.017	Chizar Booster	Distribution Reservoir No.21 & 22	6,000	4,200	2	2	1	1	0	15	82		63,000	729	
No.019	Distribution Reservoir No.19	Distribution Reservoir No.21 & 40	1,800		3		0		0		82		0	0	Not used
No.020	Distribution Reservoir No.20	Distribution Reservoir No.26	800		4		3		20		77		48,000	556	
No.21-1	Distribution Reservoir No.21	Distribution Reservoir No.20, 23 & 25	1,900	1,500	4	1	0	0	0	0			0	0	Not used
No.21-2	Distribution Reservoir No.21	Distribution Reservoir No.20, 23 & 25	1,500		2		0		0		150		0	0	Not used
NO.22-1	Distribution Reservoir No.22	Distribution Reservoir No.24	500	420	1	2	1	1	24	24	143		22,080	256	
NO.22-2	Distribution Reservoir No.22	Distribution Reservoir No.24	500	420	1	1	1	1	24	24	143		22,080	256	
NO.22-3	Distribution Reservoir No.22	Distribution Reservoir No.38	700	500	2	1	1	1	9	18	143		15,300	177	
No.024	Distribution Reservoir No.24	Distribution Reservoir No.32	600	300	2	2	2	1	16	24	142		26,400	306	
No.025	Distribution Reservoir No.25	Distribution Reservoir No.27	900		3		2		16		84		28,800	333	
No.026	Distribution Reservoir No.26	Reserovir No.28	400		2		2		12		54		9,600	111	
No.027	Distribution Reservoir No.27	Reserovir No.29	300		3		1		18		54		5,400	63	
No.028	Distribution Reservoir No.28	Elevated Tank No.33	200	100	2	1	1	1	17	4	40		3,800	44	
No.032	Distribution Reservoir No.32	Distribution Reservoir No.91	350		5		2		14		70		9,800	113	
No.34-1	Distribution Reservoir No.34	Elevated Tank No.109	150		2		1		0		238		0	0	Not used
No.34-2	Distribution Reservoir No.34	Transmission Network	150		1		0		0		60		0	0	Not used
No.036	Distribution Reservoir No.36	Distribution Reservoir No.63	500		6		4		22		102		44,000	509	
No.037	Distribution Reservoir No.37	Distribution Reservoir No.72	750	500	5	2	2	2	23	17	60		51,500	596	
No.038	Distribution Reservoir No.38	Distribution Reservoir No.82	500		4		1		24		88		12,000	139	
No.040	Distribution Reservoir No.40	Distribution Reservoir No.41	670		4		2		0		56		0	0	Not used
No.043	Distribution Reservoir No.43	Distribution Reservoir No.12	500		4		2		20		75		20,000	231	
No.52-1	Contact Tank No.52	Distribution Reservoir No.16	2,200		2		2		22		12		96,800	1,120	
No.52-2	Contact Tank No.52	Distribution Reservoir No.53	2,200		2		1		24		12		52,800	611	
No.56-1	Distribution Reservoir No.56	Distribution Reservoir No.57	2,975		5		4		22		138		261,800	3,030	
No.56-2	Distribution Reservoir No.56	Distribution Reservoir No.59	1,250		5		3		17		68		63,750	738	
No.057	Distribution Reservoir No.57	Distribution Reservoir No.58	2,875		5		3		16		79		138,000	1,597	
No.58	Distribution Reservoir No.58	Distribution Reservoir No.22 & 37	2,825		5		2		22		60		124,300	1,439	
No.059	Distribution Reservoir No.59	Distribution Reservoir No.80	800	500	3	2	2	2	24	24	70		62,400	722	
No.64	Distribution Reservoir No.64	Elevated Tank No.108													Not used
No.065	Distribution Reservoir No.65	Ringway	810		4		1		24		67		19,440	225	
No.066	Contact Tank No.66	Ringway	900		4		2		24		60		43,200	500	
No.68-1	Distribution Reservoir & Contact Tank No.68	Ringway	520		3		1		14		39.3		7,280	84	
No.68-2	Distribution Reservoir & Contact Tank No.68	Elevated Tank No.111											0	0	Not used

Pumps

No.	from	to	Pump Capacity (m3/hr)			Number of Installed Pump			Number of Working Pump			Working Hour			Head (m)	Elevation (+m)	Amount of Flow (m3/day)	Flow (Liter/sec)	Status
No.069	Distribution Reservoir & Contact Tank No.69	Elevated Tank No.112		660			3			2			10		30		13,200	153	
No.071	Distribution Reservoir No.71	Distribution Reservoir No.94		640			3			2			24		45		30,720	356	
No.072	Distribution Reservoir No.72	Distribution Reservoir No.38		920	500		4	2		2	1		13	14	83		30,920	358	
No.73-1	Distribution Reservoir No.73	Distribution Reservoir No.15		2,400	1,200		2	1		2	0		23	0	19.5		110,400	1,278	
No.73-2	Distribution Reservoir No.73	Distribution Reservoir No.15		2,700			2			2			17		19.5		91,800	1,063	
No.074	Distribution Reservoir No.74	Distribution Reservoir No.75		500			2			2			15		84		15,000	174	
No.075	Distribution Reservoir No.75	Distribution Reservoir No.77		760			3			0			0		85		0	0	Not used
No.080	Distribution Reservoir No.80	Distribution Reservoir No.81		820			5			3			17		70		41,820	484	
No.081	Distribution Reservoir No.81	Distribution Reservoir No.85		340			6			0			0		54		0	0	
No.082	Distribution Reservoir No.82	Distribution Reservoir No.83		820			2			0			0		140		0	0	
No.92-1	WTP-1 Crear Water Tank No.92	Distribution Reservoir No.1		1,400			2			1			22		60		30,800	356	
No.92-2	WTP-1 Crear Water Tank No.92	Distribution Reservoir No.2		1,400			2			1			22		60		30,800	356	
No.093	WTP-2 Crear Water Tank No.93	Distribution Reservoir No.34		400	200		1	2		1	1		22	20	112.7		12,800	148	
No.095	WTP-3 Crear Water Tank No.95	Elevated Tank No.113		300	150		1	2		1	1		22	22	60		9,900	115	
No.096	Contact Tank No.96	Transmission Network	1,000	900	300	3	1	2	2	1	2	14	24	24	25.4		64,000	741	
No.097	WTP-4 Crear Water Tank No.97	Elevated Tank No.100															0	0	Future
No.104	Gisha Booster	Distribution Reservoir No.18		500			1			1			20		82	1324	10,000	116	
No.105	Bank Sepah Pump Station	Distribution Reservoir No.12		300	200		1	2		0	0		0	0	76.7		0	0	
No.114	Tarasht Pump Station	Concrete Pipeline		1,400			1			1			24		70.5		33,600	389	

Reservoirs / Tanks

No.	Name of Facilities	Location	Capacity (m3)	Top Water Level (+m)	Low Water Level (+m)	Water Depth (m)	Existing / Future	Status
	Booster Station							
No.017	Booster Station	Chizar Booster					Existing	
No.104	Booster Station	Gisha Boosters					Existing	
No.105	Booster Station	Sepah Bank Boosters					Existing	
No.114	Booster Station	Tarasht Pump Station	4,870	1,259.00			Existing	
	Break Pressure Tank							
No.044	Break Pressure Tank	Majidieh Pressure Reducer	2,500	1,332.00	1,327.30	4.70	Existing	Not Using
No.076	Break Pressure Tank	Tehran Pars Pressure Reducer	2,400	1,364.00	1,359.00	5.00	Existing	
	Clear Water Tank							
No.092	Clear Water Tank	1st Treatment Plant Reservoir	3,000	1,247.00			Existing	
No.093	Clear Water Tank	2nd Treatment Plant Reservoir	50,000	1,330.00			Existing	
No.095	Clear Water Tank	3rd Treatment plant	34,000	1,509.00			Existing	
No.097	Clear Water Tank	4th Treatment Plant Reservoir	34,000	1,509.00			Existing	
No.099	Clear Water Tank	5th Treatment Plant Reservoir	20,000	1,689.00			Existing	
	Contact Tank							
No.052	Contact Tank	Esfahanak	20,000	1,151.00	1,146.30	4.70	Existing	
No.065	Contact Tank	Khaniabad	19,000	1,096.00	1,092.00	4.00	Existing	
No.066	Contact Tank	Shariati	17,000	1,103.00	1,099.00	4.00	Existing	
No.069	Contact Tank	Ferdows	20,000	1,140.00	1,133.20	6.80	Existing	
No.073	Contact Tank	Yaftabad	20,000	1,144.00	1,140.00	4.00	Existing	
No.096	Contact Tank	Southern Tarasht	2,700	1,214.00	1,209.50	4.50	Existing	
	Reservoir & Contact Tank							
No.068	Reservoir & Contact Tank	Valiasr	20,000	1,121.00	1,114.20	6.80	Existing	
No.089	Reservoir & Contact Tank	Freshfruit & Vegetable Square	20,000	1,090.00	1,084.20	5.80	Existing	
	Distribution Reservoir		98,700					
No.001	Distribution Reservoir	Yousefabad	75,600	1,307.00	1,302.25	4.75	Existing	
No.002	Distribution Reservoir	Bisim	74,000	1,307.00	1,302.50	4.50	Existing	
No.003	Distribution Reservoir	Amirabad	55,500	1,239.00	1,234.50	4.50	Existing	
No.004	Distribution Reservoir	Behjatabad	55,500	1,239.00	1,234.50	4.50	Existing	
No.005	Distribution Reservoir	Bahar	55,500	1,239.00	1,234.50	4.50	Existing	
No.006	Distribution Reservoir	Eshratabad	55,500	1,239.00	1,234.50	4.50	Existing	
No.007	Distribution Reservoir	Resalat - Majidieh	55,500	1,307.00	1,302.33	4.67	Existing	
No.008	Distribution Reservoir	Upper Amirabad	57,600	1,307.00	1,302.33	4.67	Existing	
No.009	Distribution Reservoir	Lower Yousefabad	18,500	1,367.00	1,360.33	6.67	Existing	
No.010	Distribution Reservoir	Abbasabad	36,500	1,359.00	1,352.33	6.67	Existing	
No.011	Distribution Reservoir	Narmak	38,400	1,359.00	1,352.33	6.67	Existing	
No.012	Distribution Reservoir	Sepah Bank	5,000	1,552.00	1,547.30	4.70	Existing	
No.013	Distribution Reservoir	Karaj Road	55,500	1,239.00	1,233.75	5.25	Existing	
No.014	Distribution Reservoir	Upper Yousefabad	25,000	1,448.00	1,443.30	4.70	Existing	
No.015	Distribution Reservoir	Mehrabad	55,500	1,163.00	1,157.75	5.25	Existing	
No.016	Distribution Reservoir	Soleymanieh	55,500	1,163.00	1,157.75	5.25	Existing	
No.018	Distribution Reservoir	Gisha	2,500	1,417.00	1,412.25	4.75	Existing	
No.019	Distribution Reservoir	Mobarakabad	20,500	1,444.00	1,439.30	4.70	Existing	
No.020	Distribution Reservoir	Lower Hesarak	33,000	1,676.00	1,668.00	8.00	Existing	
No.021	Distribution Reservoir	Chizar	27,000	1,526.00	1,521.30	4.70	Existing	
No.022	Distribution Reservoir	Vanak	37,000	1,522.00	1,517.30	4.70	Existing	
No.023	Distribution Reservoir	Niavaran	31,600	1,669.00	1,661.40	7.60	Existing	
No.024	Distribution Reservoir	Mahmoudieh	34,000	1,665.00	1,657.40	7.60	Existing	
No.025	Distribution Reservoir	Lower Manzarieh	31,000	1,669.00	1,661.40	7.60	Existing	
No.026	Distribution Reservoir	Upper Hesarak	52,500	1,753.00	1,745.00	8.00	Existing	
No.027	Distribution Reservoir	Upper Manzarieh	12,000	1,753.00	1,745.40	7.60	Existing	
No.028	Distribution Reservoir	Darband	7,000	1,807.00	1,799.40	7.60	Existing	
No.029	Distribution Reservoir	Azargah	6,700	1,807.00	1,799.00	8.00	Existing	
No.030	Distribution Reservoir	Velenjak	4,000	1,753.00	1,748.30	4.70	Existing	
No.031	Distribution Reservoir	Tehran now	37,000	1,239.00	1,234.30	4.70	Existing	
No.032	Distribution Reservoir	Aliabad + Ext.	22,200	1,807.00	1,802.30	4.70	Existing	
No.034	Distribution Reservoir	Shahran	7,700	1,442.00	1,437.60	4.40	Existing	
No.035	Distribution Reservoir	Shahrake Ghods					Future	Cancelled
No.036	Distribution Reservoir	Moshirieh	43,700	1,137.00	1,132.30	4.70	Existing	
No.037	Distribution Reservoir	Lower Farahzad	45,000	1,522.00	1,514.40	7.60	Existing	
No.038	Distribution Reservoir	Evin + Ext.	64,000	1,665.00	1,657.40	7.60	Existing	
No.039	Distribution Reservoir	Zargandeh	13,800	1,448.00	1,440.40	7.60	Existing	Not used

Reservoirs / Tanks

No.	Name of Facilities	Location	Capacity (m3)	Top Water Level (+m)	Low Water Level (+m)	Water Depth (m)	Existing / Future	Status
No.040	Distribution Reservoir	Pasdaran	14,300	1,526.00	1,518.50	7.50	Existing	
No.041	Distribution Reservoir	Saheb Qaranieh	27,500	1,582.00	1,574.40	7.60	Existing	
No.043	Distribution Reservoir	Tehran Pars	44,000	1,477.00	1,469.40	7.60	Existing	
No.045	Distribution Reservoir	Lavizan	20,000	1,582.00			Future	
No.046	Distribution Reservoir	Lower Lashgarak	20,000	1,669.00			Future	
No.048	Distribution Reservoir	Imam Hossein	20,000	1,582.00			Future	
No.049	Distribution Reservoir	Imam Hossein	10,000	1,669.00			Future	
No.050	Distribution Reservoir	Imam Hossein	10,000	1,753.00			Future	
No.051	Distribution Reservoir	Qasr-e-Firouzeh	65,000	1,239.00	1,231.20	7.80	Existing	
No.053	Distribution Reservoir	Soleymanieh No.2	33,000	1,163.00	1,157.80	5.20	Existing	
No.054	Distribution Reservoir	Aria Shahr	34,000	1,307.00			Existing	Not used
No.055	Distribution Reservoir	Bagh Feiz	42,000	1,372.00	1,364.40	7.60	Existing	
No.056	Distribution Reservoir	Kan	26,800	1,324.00	1,316.40	7.60	Existing	
No.057	Distribution Reservoir	Jannatabad + Ext.	47,000	1,392.00	1,384.40	7.60	Existing	
No.058	Distribution Reservoir	Lower Pounak + Ext.	44,200	1,462.00	1,454.40	7.60	Existing	
No.059	Distribution Reservoir	North Kan	30,000	1,462.00	1,454.40	7.60	Existing	
No.060	Distribution Reservoir	Molla Sadra					Future	
No.061	Distribution Reservoir	Northern Amirabad	32,000	1,367.00	1,360.30	6.70	Existing	Not used
No.062	Break Pressure Tank	Kazemabad	22,000	1,359.00	1,351.50	7.50	Existing	Not used
No.063	Distribution Reservoir	Upper Massoudieh	10,000	1,239.00	1,231.50	7.50	Existing	
No.064	Distribution Reservoir	Afsarieh Reservoir	16,500	1,171.00			Existing	
No.070	Distribution Reservoir	17th Shahrivar	12,500	1,155.00	1,151.00	4.00	Future	
No.071	Distribution Reservoir	Tehran Pars Treatment Plant	20,000	1,509.00	1,502.80	6.20	Existing	
No.072	Distribution Reservoir	Saadatabad	22,000	1,582.00	1,574.20	7.80	Existing	
No.074	Distribution Reservoir	Lower Aqdasieh	10,000	1,669.00	1,661.50	7.50	Existing	
No.075	Distribution Reservoir	Upper Aqdasieh	10,000	1,753.00	1,746.20	6.80	Existing	
No.077	Distribution Reservoir	Upper Baqlazar	10,000	1,838.00	1,833.50	4.50	Existing	Not used
No.078	Distribution Reservoir	Lower Sohanak		1,753.00			Future	
No.079	Distribution Reservoir	Upper Sohanak	10,000	1,838.00			Future	
No.080	Distribution Reservoir	Lower Hesarak	36,000	1,532.00	1,525.00	7.00	Existing	
No.081	Distribution Reservoir	Upper Hesarak	20,000	1,602.00	1,597.50	4.50	Existing	
No.082	Distribution Reservoir	Lower Kahrizak	10,000	1,753.00	1,748.50	4.50	Existing	
No.083	Distribution Reservoir	Upper Kahrizak	20,000	1,807.00			Future	Under Construction
No.084	Distribution Reservoir	Lower Moradabad	10,000	1,672.00			Future	
No.085	Distribution Reservoir	Upper Moradabad	17,500	1,742.00			Future	Under Construction
No.086	Distribution Reservoir	Lower Hor	17,500	1,149.00	1,143.75	5.25	Future	
No.087	Distribution Reservoir	Upper Hor	17,500	1,151.00	1,144.60	6.40	Future	
No.088	Distribution Reservoir	Northern Mehrabad					Future	
No.091	Distribution Reservoir	Upper Aliabad	12,000	1,877.00	1,872.50	4.50	Existing	
No.094	Distribution Reservoir	3rd Treatment Plant Reservoir	25,000	1,550.00			Existing	
No.098	Distribution Reservoir	Jey Garrison	8,000				Future	
No.103	Distribution Reservoir	6th Treatment Plant		1,560.00			Future	
	Elevated Tank							
No.033	Elevated Tank	Upper Darband	400	1,832.00	1,827.30	4.70	Existing	
No.108	Elevated Tank	Afsarieh elevated Tank	1,000	1,200.00			Existing	Not used
No.109	Elevated Tank	Shahran elevated Tank	500	1,680.00			Existing	Not used
No.110	Elevated Tank	17th Shahrivar elevated tank	500	1,181.00			Future	
No.111	Elevated Tank	Valiasr elevated Tank	1,500	1,153.00			Existing	Not used
No.112	Elevated Tank	Ferdows elevated Tank	500	1,170.00			Existing	
No.113	Elevated Tank	3rd Treatment Plant	50	1,580.00			Existing	

APPENDIX-8

Data on Hydraulic Analysis

Appendix 8-2

Data of Transmission Network Model

Table 1: Nodes

Table 2: Pipes

Table 3: Tanks/reservoirs

Table 4: Pumps

Table 5: Valvas

Section 2: Transmission Network Model Table 1: Nodes

Label	Elevation (m)	Type	Base Flow (m3/day)	Demand (Calculated) (m3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)
Well-802-1	1,018.00	Inflow	86,180	-86,180	1,023.18	5.17
Well-802-2	1,014.00	Inflow	113,920	-113,920	1,018.28	4.27
Well-803	1,020.00	Inflow	13,200	-13,200	1,024.10	4.09
Well-804	1,021.00	Inflow	8,400	-8,400	1,025.00	3.99
Well-805	938.00	Inflow	43,200	-43,200	942.07	4.06
Well-806	946.00	Inflow	12,960	-12,960	950.01	4.00
Well-807	958.00	Inflow	13,920	-13,920	964.01	6.00
Well-808	1,027.00	Inflow	32,640	-32,640	1,027.33	0.33
Well-809	1,043.00	Inflow	35,520	-35,520	1,047.94	4.93
Well-810	1,031.00	Inflow	146,250	-146,250	1,035.35	4.34
Well-811	983.00	Inflow	48,570	-48,570	988.05	5.04
Well-812	1,069.00	Inflow	75,060	-75,060	1,073.08	4.08
Well-813	1,039.00	Inflow	63,300	-63,300	1,044.30	5.29
Well-814	1,100.00	Inflow	73,510	-73,510	1,103.20	3.19
Well-815	1,124.00	Inflow	21,120	-21,120	1,128.02	4.01
Well-816	1,099.00	Inflow	22,800	-22,800	1,103.01	4.01
Well-818	1,093.00	Inflow	13,200	-13,200	1,098.01	5.00
Well-820	1,127.00	Inflow	33,288	-33,288	1,132.89	5.88
Well-821	1,127.00	Inflow	36,062	-36,062	1,131.74	4.73
Well-822	1,201.00	Inflow	9,600	-9,600	1,206.00	4.99
Well-823	1,115.00	Inflow	34,560	-34,560	1,131.25	16.21
Well-824	1,125.00	Inflow	7,920	-7,920	1,140.14	15.11
Well-825	1,160.00	Inflow	42,240	-42,240	1,163.68	3.67
Well-828	1,391.00	Inflow	12,000	-12,000	1,395.01	4.00
Well-831	1,351.00	Inflow	27,000	-27,000	1,355.51	4.51
Well-832	1,267.00	Inflow	16,800	-16,800	1,268.01	1.01
Well-833	1,299.00	Inflow	5,670	-5,670	1,303.00	3.99
Well-891	1,107.00	Inflow	5,040	-5,040	1,120.13	13.10
Well-892	1,118.00	Inflow	58,202	-58,202	1,130.11	12.09
WTP-1	1,247.00	Inflow	195,038	-195,038	1,256.23	9.21
WTP-2	1,330.00	Inflow	787,026	-787,026	1,323.59	-6.40
WTP-3	1,509.00	Inflow	401,200	-401,200	1,510.00	1.00
WTP-4	1,509.00	Inflow	397,700	-397,700	1,510.00	1.00
WTP-5	1,689.00	Inflow	279,900	-279,900	1,695.00	5.99
CWT-092	1,240.00	Demand	0	0	1,256.23	16.19
CWT-093	1,323.00	Demand	0	0	1,323.59	0.59
CWT-095	1,509.00	Demand	0	0	1,510.00	1.00
CWT-097	1,509.00	Demand	0	0	1,510.00	1.00
CWT-099	1,682.00	Demand	0	0	1,695.00	12.97
J-200	1,159.00	Demand	0	0	1,162.55	3.54
J-381	1,473.00	Demand	0	0	1,525.05	51.95
J-382	1,451.00	Demand	0	0	1,524.83	73.68
J-391	1,440.00	Demand	10,800	10,800	1,529.44	89.26
J-392	1,490.00	Demand	16,934	16,934	1,524.64	34.57
J-393	1,517.00	Demand	0	0	1,523.97	6.96
J-394	1,512.00	Demand	10,800	10,800	1,523.82	11.79
J-401	1,661.00	Demand	0	0	1,675.85	14.82
J-411	1,661.00	Demand	0	0	1,675.85	14.82
J-420	1,729.00	Demand	0	0	1,810.22	81.06
J-421	1,710.00	Demand	7,197	7,197	1,800.55	90.37
J-422	1,711.00	Demand	7,374	7,374	1,798.99	87.81
J-431	1,389.00	Demand	0	0	1,390.96	1.96
J-441	1,448.00	Demand	0	0	1,521.91	73.77
J-442	1,515.00	Demand	0	0	1,521.89	6.88
J-451	1,638.00	Demand	0	0	1,693.99	55.88
J-452	1,638.00	Demand	0	0	1,693.98	55.87
J-453	1,585.00	Demand	0	0	1,693.11	107.89
J-461	1,638.00	Demand	0	0	1,694.15	56.04
J-462	1,585.00	Demand	0	0	1,693.12	107.90
J-471	1,581.00	Demand	0	0	1,693.09	111.86
J-472	1,575.00	Demand	0	0	1,691.54	116.30
J-473	1,570.00	Demand	0	0	1,691.02	120.77
J-481	1,561.00	Demand	0	0	1,690.74	129.48
J-482	1,630.00	Demand	0	0	1,687.90	57.78
J-483	1,661.00	Demand	0	0	1,682.71	21.67
J-490	1,480.00	Demand	0	0	1,525.13	45.04
J-491	1,561.00	Demand	0	0	1,690.73	129.47
J-492	1,630.00	Demand	0	0	1,687.94	57.82
J-520	1,545.00	Demand	0	0	1,549.21	4.20
J-521	1,340.00	Demand	0	0	1,489.20	148.90
J-522	1,300.00	Demand	0	0	1,474.04	173.69
J-530	1,411.00	Demand	0	0	1,504.82	93.63
J-531	1,502.00	Demand	0	0	1,509.14	7.12
J-532	1,364.00	Demand	0	0	1,475.81	111.58
J-533	1,355.00	Demand	0	0	1,362.75	7.74
J-540	1,502.00	Demand	0	0	1,507.86	5.85
J-541	1,489.00	Demand	0	0	1,496.25	7.24
J-541-2	1,450.00	Demand	0	0	1,494.14	44.05
J-542	1,411.00	Demand	0	0	1,492.24	81.08
J-543	1,411.00	Demand	0	0	1,501.32	90.14

Section 2: Transmission Network Model Table 1: Nodes

Label	Elevation (m)	Type	Base Flow (m3/day)	Demand (Calculated) (m3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)
J-201	1,135.00	Demand	0	0	1,160.75	25.70
J-202	1,129.00	Demand	0	0	1,160.01	30.95
J-203	1,122.00	Demand	28,676	28,676	1,159.36	37.29
J-204	1,115.00	Demand	42,216	42,216	1,157.99	42.90
J-206	1,105.00	Demand	0	0	1,157.67	52.56
J-207	1,100.00	Demand	28,631	28,631	1,157.35	57.23
J-208	1,095.00	Demand	0	0	1,155.96	60.84
J-209	1,097.50	Demand	0	0	1,154.73	57.11
J-210	1,100.00	Demand	28,631	28,631	1,154.41	54.30
J-211	1,116.00	Demand	28,631	28,631	1,153.38	37.31
J-212	1,113.00	Demand	0	0	1,153.03	39.95
J-213	1,113.00	Demand	28,631	28,631	1,152.56	39.48
J-214	1,117.50	Demand	28,631	28,631	1,151.00	33.43
J-215	1,129.50	Demand	28,679	28,679	1,150.50	20.96
J-216	1,139.00	Demand	28,631	28,631	1,150.49	11.47
J-217	1,135.60	Demand	92,836	92,836	1,150.74	15.11
J-217-1	1,130.00	Demand	0	0	1,151.16	21.11
J-217-2	1,143.00	Demand	42,216	42,216	1,152.11	9.10
J-218	1,142.00	Demand	0	0	1,152.09	10.07
J-218-1	1,144.00	Demand	0	0	1,152.39	8.37
J-218-2	1,144.00	Demand	0	0	1,152.49	8.48
J-219	1,144.00	Demand	0	0	1,152.51	8.49
J-221	1,155.00	Demand	0	0	1,160.50	5.49
J-231	1,144.00	Demand	0	0	1,152.50	8.48
J-240	1,197.00	Demand	42,216	42,216	1,237.87	40.78
J-241	1,200.50	Demand	0	0	1,237.85	37.28
J-241-1	1,190.00	Demand	0	0	1,237.66	47.57
J-242	1,192.00	Demand	43,978	43,978	1,237.49	45.40
J-243	1,198.00	Demand	5,616	5,616	1,237.49	39.41
J-244	1,214.50	Demand	43,891	43,891	1,236.05	21.51
J-244-1	1,215.50	Demand	43,891	43,891	1,235.95	20.41
J-245	1,217.50	Demand	0	0	1,236.61	19.07
J-245-1	1,215.00	Demand	14,342	14,342	1,235.90	20.86
J-245-2	1,212.50	Demand	43,891	43,891	1,235.55	23.00
J-246	1,210.00	Demand	22,464	22,464	1,235.61	25.56
J-246-1	1,211.00	Demand	14,342	14,342	1,235.33	24.28
J-247	1,210.00	Demand	72,576	72,576	1,235.22	25.17
J-247-1	1,210.00	Demand	43,978	43,978	1,234.61	24.56
J-247-2	1,210.00	Demand	14,342	14,342	1,234.62	24.57
J-248	1,210.50	Demand	72,576	72,576	1,234.83	24.28

Label	Elevation (m)	Type	Base Flow (m3/day)	Demand (Calculated) (m3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)
J-543-1	1,407.00	Demand	30,311	30,311	1,499.33	92.15
J-543-2	1,403.00	Demand	0	0	1,498.71	95.52
J-544	1,411.00	Demand	0	0	1,489.17	78.01
J-545	1,411.50	Demand	9,869	9,869	1,486.98	75.33
J-546	1,412.00	Demand	39,515	39,515	1,485.83	73.68
J-551	1,450.00	Demand	89,242	89,242	1,494.12	44.03
J-552	1,411.00	Demand	89,242	89,242	1,489.12	77.96
J-553	1,412.00	Demand	0	0	1,485.64	73.49
J-553-1	1,407.00	Demand	0	0	1,482.49	75.33
J-554	1,402.00	Demand	0	0	1,480.77	78.61
J-555	1,385.00	Demand	0	0	1,396.04	11.02
J-560	1,522.00	Demand	0	0	1,545.75	23.70
J-561	1,515.00	Demand	0	0	1,525.01	9.99
J-562	1,520.00	Demand	0	0	1,525.00	4.99
J-571	1,350.00	Demand	2,074	2,074	1,355.34	5.33
J-572	1,306.00	Demand	4,752	4,752	1,343.17	37.10
J-573	1,306.00	Demand	13,133	13,133	1,343.12	37.04
J-574	1,307.00	Demand	13,219	13,219	1,343.06	35.99
J-575	1,309.00	Demand	3,283	3,283	1,341.83	32.76
J-576	1,311.00	Demand	4,752	4,752	1,339.44	28.38
J-577	1,311.00	Demand	2,074	2,074	1,338.65	27.59
J-578	1,310.00	Demand	4,752	4,752	1,330.40	20.36
J-579	1,315.00	Demand	0	0	1,329.87	14.84
J-581	1,332.00	Demand	0	0	1,340.62	8.60
J-582	1,327.00	Demand	0	0	1,340.54	13.52
J-583	1,310.00	Demand	0	0	1,330.20	20.16
J-591	1,359.00	Demand	0	0	1,442.98	83.81
J-592	1,351.00	Demand	0	0	1,442.98	91.79
J-593	1,310.00	Demand	13,133	13,133	1,338.27	28.21
J-593-1	1,310.00	Demand	0	0	1,442.96	132.69
J-601	1,217.00	Demand	57,103	57,103	1,234.24	17.21
J-602	1,210.00	Demand	49,603	49,603	1,220.36	10.34
J-603	1,200.00	Demand	0	0	1,220.36	20.32
J-611	1,197.00	Demand	45,274	45,274	1,220.35	23.30
J-612	1,185.00	Demand	0	0	1,241.76	56.65
J-631	1,245.00	Demand	0	0	1,258.32	13.30
J-632	1,247.00	Demand	0	0	1,260.12	13.09
J-633	1,248.00	Demand	0	0	1,260.13	12.11
J-990	1,245.00	Demand	0	0	1,257.88	12.86
J-991	1,248.00	Demand	0	0	1,260.00	11.98

Section 2: Transmission Network Model Table 1: Nodes

Label	Elevation (m)	Type	Base Flow (m3/day)	Demand (Calculated) (m3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)
J-251	1,242.00	Demand	0	0	1,252.86	10.84
J-252	1,239.00	Demand	0	0	1,254.82	15.79
J-253	1,239.00	Demand	0	0	1,254.57	15.53
J-254	1,230.00	Demand	0	0	1,248.05	18.01
J-255	1,230.00	Demand	0	0	1,245.88	15.85
J-256	1,235.00	Demand	0	0	1,243.27	8.26
J-261	1,255.00	Demand	0	0	1,307.09	51.99
J-271	1,320.00	Demand	0	0	1,323.36	3.35
J-272	1,316.00	Demand	0	0	1,323.26	7.25
J-281	1,315.00	Demand	0	0	1,322.93	7.91
J-282	1,295.00	Demand	68,549	68,549	1,321.53	26.48
J-283	1,269.50	Demand	0	0	1,321.53	51.93
J-291	1,276.50	Demand	0	0	1,321.53	44.94
J-300	1,310.00	Demand	74,218	74,218	1,320.86	10.84
J-301	1,300.00	Demand	0	0	1,320.40	20.36
J-302	1,302.00	Demand	0	0	1,317.46	15.43
J-303	1,280.00	Demand	0	0	1,316.52	36.45
J-304	1,263.00	Demand	0	0	1,312.21	49.11
J-305	1,262.00	Demand	0	0	1,310.85	48.75
J-306	1,288.00	Demand	0	0	1,306.22	18.19
J-307	1,230.00	Demand	39,744	39,744	1,298.44	68.30
J-308	1,286.00	Demand	0	0	1,312.21	26.16
J-311	1,210.00	Demand	6,912	6,912	1,227.85	17.81
J-312	1,200.00	Demand	10,800	10,800	1,221.68	21.64
J-313	1,180.00	Demand	10,800	10,800	1,215.44	35.37
J-314	1,160.00	Demand	21,254	21,254	1,212.14	52.03
J-321	1,295.50	Demand	0	0	1,319.86	24.31
J-322	1,302.00	Demand	0	0	1,318.08	16.05
J-331	1,449.00	Demand	0	0	1,461.07	12.05
J-341	1,351.00	Demand	0	0	1,447.70	96.50
J-342	1,440.00	Demand	0	0	1,447.09	7.08
J-350	1,345.00	Demand	0	0	1,446.92	101.72
J-351	1,363.00	Demand	0	0	1,447.26	84.10
J-352	1,400.00	Demand	0	0	1,416.66	16.62
J-361	1,440.00	Demand	9,504	9,504	1,447.09	7.08
J-370	1,443.00	Demand	0	0	1,524.81	81.64
J-371	1,438.00	Demand	0	0	1,524.63	86.46
J-372	1,517.00	Demand	0	0	1,524.02	7.01
J-992	1,315.00	Demand	0	0	1,363.04	47.95
J-PMP-016	1,157.00	Demand	0	0	1,238.34	81.18
J-PMP-019	1,441.70	Demand	0	0	1,517.37	75.51
J-PMP-021	1,523.00	Demand	0	0	1,525.00	2.00
J-PMP-021	1,523.00	Demand	0	0	1,525.00	2.00
J-PMP-024	1,650.00	Demand	0	0	1,813.13	162.81
J-PMP-040	1,525.00	Demand	0	0	1,600.74	75.58
Well-817	1,239.00	Demand	0	0	1,245.88	6.87
Well-819	1,079.00	Demand	0	0	1,489.20	409.38
Well-827	1,402.00	Demand	0	0	1,521.00	118.76
Well-830	1,402.00	Demand	0	0	1,581.00	178.64

Section 2: Transmission Network Model

Table 2: Pipe Elements

Label	From Node	To Node	Material	Diameter (mm)	Length (m)	Hazen-Williams C	Check Valve?	Control Status	Discharge (m3/day)	Velocity (m/s)	Pipe Headloss (m)	Headloss Gradient (m/km)
Bypass-PMP-016-2	J-PMP-016-2	Res-016	Steel	900	58	100	FALSE	Closed	0	0.00	0.00	0.00
Bypass-PMP-040	Res-040	J-PMP-040	Steel	700	1	100	FALSE	Closed	0	0.00	0.00	0.00
P-14	J-541	BS-105	Ductile Iron	600	119	110	FALSE	Closed	0	0.00	0.00	0.00
P-15	BS-105	Res-012	Ductile Iron	600	848	110	FALSE	Closed	0	0.00	0.00	0.00
P-20	J-PMP-040	J-473	Ductile Iron	700	1,055	110	FALSE	Closed	0	0.00	0.00	0.00
P-285	J-593	J-583	Steel	900	51	100	FALSE	Closed	0	0.00	0.00	0.00
P-289	J-301	Res-054	Steel	1,000	379	100	FALSE	Closed	0	0.00	0.00	0.00
P-33	J-532	J-533	Steel	800	71	100	FALSE	Closed	0	0.00	0.00	0.00
P-339	Res-073	Res-069	Steel	700	480	100	FALSE	Closed	0	0.00	0.00	0.00
P-353	J-306	FCV-Res007-Out	Concrete	1,350	605	100	FALSE	Closed	0	0.00	0.00	0.00
P-354	Res-068	PMP-068-2	Ductile Iron	500	1	110	FALSE	Closed	0	0.00	0.00	0.00
P-355	PMP-068-2	ET-111	Ductile Iron	500	61	110	FALSE	Closed	0	0.00	0.00	0.00
P-356	FCV-Res007-Out	Res-007	Concrete	1,350	15	100	FALSE	Closed	0	0.00	0.00	0.00
P-364	J-208	Res-089	Steel	500	2,641	100	FALSE	Closed	0	0.00	0.00	0.00
P-391	Res-034	PMP-034-2	Ductile Iron	600	1	110	FALSE	Closed	0	0.00	0.00	0.00
P-392	PMP-034-2	J-331	Ductile Iron	600	454	110	FALSE	Closed	0	0.00	0.00	0.00
P-411	Res-040	FCV-Res040-Out-2	Steel	700	1	100	FALSE	Closed	0	0.00	0.00	0.00
P-413	FCV-Res040-Out-2	PMP-040	Steel	700	1	100	FALSE	Closed	0	0.00	0.00	0.00
P-415	Res-021	FCV-Res021-Out-1	Steel	1,200	1	100	FALSE	Closed	0	0.00	0.00	0.00
P-417	FCV-Res021-Out-1	PMP-021-1	Steel	1,200	1	100	FALSE	Closed	0	0.00	0.00	0.00
P-419	Res-021	FCV-Res021-Out-2	Steel	1,000	1	100	FALSE	Closed	0	0.00	0.00	0.00
P-42	J-581	BPT-044	Steel	900	49	100	FALSE	Closed	0	0.00	0.00	0.00
P-420	FCV-Res021-Out-2	PMP-021-2	Steel	1,000	1	100	FALSE	Closed	0	0.00	0.00	0.00
P-43	BPT-044	J-582	Steel	900	62	100	FALSE	Closed	0	0.00	0.00	0.00
P-46	J-591	Res-062	Steel	1,200	322	100	FALSE	Closed	0	0.00	0.00	0.00
P-466	J-553-1	J-543-1	Ductile Iron	1,200	12	110	FALSE	Closed	0	0.00	0.00	0.00
P-47	Res-062	J-592	Steel	1,200	337	100	FALSE	Closed	0	0.00	0.00	0.00
P-508	FCV-Res019-In-2	Res-019	Ductile Iron	1,200	1	110	FALSE	Closed	0	0.00	0.00	0.00
P-509	J-PMP-019	FCV-Res019-In-2	Ductile Iron	1,200	1	110	FALSE	Closed	0	0.00	0.00	0.00
P-510	J-462	FCV-J462-Out	Ductile Iron	700	4	110	FALSE	Closed	0	0.00	0.00	0.00
P-511	FCV-J462-Out	J-560	Ductile Iron	700	734	110	FALSE	Closed	0	0.00	0.00	0.00
P-535	Res-019	FCV-Res019-Out	Steel	1,200	10	100	FALSE	Closed	0	0.00	0.00	0.00
P-536	J-283	FCV-Res013-In	Steel	1,000	14	100	FALSE	Closed	0	0.00	0.00	0.00
P-537	FCV-Res013-In	Res-013	Steel	1,000	1366	100	FALSE	Closed	0	0.00	0.00	0.00
P-54	J-PMP-019	J-560	Steel	1,200	3,518	100	FALSE	Closed	0	0.00	0.00	0.00
P-540	CWT-093	FCV-CWT093-Out	Steel	1,200	22	100	FALSE	Closed	0	0.00	0.00	0.00
P-541	FCV-CWT093-Out	J-281	Steel	1,200	226	100	FALSE	Closed	0	0.00	0.00	0.00
P-542	FCV-Res019-Out	PMP-019	Steel	1,200	12	100	FALSE	Closed	0	0.00	0.00	0.00
P-543	FCV-Res074-In-2	Res-074	Ductile Iron	500	4594	110	FALSE	Closed	0	0.00	0.00	0.00
P-544	J-483	FCV-Res074-In-2	Ductile Iron	500	5	110	FALSE	Closed	0	0.00	0.00	0.00
P-55	J-560	J-561	Steel	1200	246	100	FALSE	Closed	0	0.00	0.00	0.00
P-568	J-583	FCV-Res007-In-1	Steel	900	112	100	FALSE	Closed	0	0.00	0.00	0.00
P-569	FCV-Res007-In-1	Res-007	Steel	900	55	100	FALSE	Closed	0	0.00	0.00	0.00
P-59	Res-034	ET-109	Steel	250	2528	100	FALSE	Closed	0	0.00	0.00	0.00
P-60	Res-001	PMP-001-3	Steel	800	26	100	FALSE	Closed	0	0.00	0.00	0.00
P-62	PMP-040	J-PMP-040	Steel	700	1	100	FALSE	Closed	0	0.00	0.00	0.00
P-623	J-530	Res-043	Steel	1400	137	100	FALSE	Closed	0	0.00	0.00	0.00
P-63	PMP-001-3	Res-061	Steel	800	2595	100	FALSE	Closed	0	0.00	0.00	0.00
P-634	J-382	Res-039	Ductile Iron	600	310	110	FALSE	Closed	0	0.00	0.00	0.00
P-71	J-451	J-461	Steel	1600	8	100	FALSE	Closed	0	0.00	0.00	0.00
P-76	Res-075	PMP-075	Steel	700	1	100	FALSE	Closed	0	0.00	0.00	0.00
P-77	PMP-075	Res-077	Steel	800	995	100	FALSE	Closed	0	0.00	0.00	0.00
P-93	PMP-021-1	J-PMP-021-1	Steel	1,200	1	100	FALSE	Closed	0	0.00	0.00	0.00
P-95	PMP-021-2	J-PMP-021-2	Steel	1,000	1	100	FALSE	Closed	0	0.00	0.00	0.00
P-PMP-817	PMP-817	J-255	Steel	1,000	179	100	FALSE	Closed	0	0.00	0.00	0.00
P-PMP-819	PMP-819	J-521	Steel	1,000	268	100	FALSE	Closed	0	0.00	0.00	0.00
P-PMP-827	PMP-827	Res-022	Steel	1,000	83	100	FALSE	Closed	0	0.00	0.00	0.00
P-PMP-830	PMP-830	Res-041	Steel	1,000	62	100	FALSE	Closed	0	0.00	0.00	0.00
P-Well-817	Well-817	PMP-817	Steel	1,000	1	100	FALSE	Closed	0	0.00	0.00	0.00
P-Well-819	Well-819	PMP-819	Steel	1,000	1	100	FALSE	Closed	0	0.00	0.00	0.00
P-Well-827	Well-827	PMP-827	Steel	1,000	1	100	FALSE	Closed	0	0.00	0.00	0.00
P-Well-830	Well-830	PMP-830	Steel	1,000	1	100	FALSE	Closed	0	0.00	0.00	0.00
Bypass-PMP-21-1	J-PMP-021-1	Res-021	Steel	1,200	1	100	FALSE	Open	5,577	0.06	0.00	0.00
Bypass-PMP-21-2	J-PMP-021-2	Res-021	Steel	1000	35	100	FALSE	Open	4,500	0.07	0.00	0.01
P-1	PMP-024	J-PMP-024	Steel	800	25	100	TRUE	Open	28,905	0.67	0.02	0.82
P-10	WTP-2	CWT-093	Steel	4,000	1	100	FALSE	Open	787,026	0.72	0.00	0.15
P-100	J-481	J-491	Steel	1600	10	100	FALSE	Open	154,354	0.89	0.01	0.63
P-101	FCV-Res028-In	PMP-026	Ductile Iron	400	1	110	FALSE	Open	10,971	1.01	0.00	3.27
P-102	J-481	J-482	Steel	1,000	1,521	100	TRUE	Open	80,897	1.19	2.84	1.87
P-103	J-491	J-492	Steel	1200	1,176	100	TRUE	Open	148,777	1.52	2.79	2.37
P-104	J-482	J-483	Steel	900	1165	100	FALSE	Open	98,064	1.78	5.19	4.45
P-105	J-492	J-482	Steel	900	235	100	FALSE	Open	17,167	0.31	0.04	0.18
P-106	J-492	FCV-Res025-In	Steel	900	271	100	FALSE	Open	28,800	0.52	0.12	0.46
P-108	PMP-025	Res-027	Ductile Iron	600	1855	110	FALSE	Open	28,800	1.18	5.16	2.78
P-110	PMP-027	Res-029	Ductile Iron	500	333	110	TRUE	Open	4,879	0.29	0.08	0.25
P-113	FCV-Res025-In	Res-025	Steel	900	25	100	FALSE	Open	28,800	0.52	0.01	0.46
P-116	J-571	J-572	Steel	800	2061	100	FALSE	Open	83,755	1.93	12.17	5.90
P-117	J-572	J-573	Steel	800	10	100	FALSE	Open	79,003	1.82	0.05	5.30
P-118	J-573	J-574	Steel	800	15	100	FALSE	Open	65,870	1.52	0.06	3.78
P-119	J-574	J-575	Steel	800	494	100	FALSE	Open	52,651	1.21	1.23	2.50

Section 2: Transmission Network Model
Table 2: Pipe Elements

Label	From Node	To Node	Material	Diameter (mm)	Length (m)	Hazen-Williams C	Check Valve?	Control Status	Discharge (m3/day)	Velocity (m/s)	Pipe Headloss (m)	Headloss Gradient (m/km)
P-12	CWT-095	PMP-095	Ductile Iron	500	1	110	FALSE	Open	9,936	0.59	0.00	1.04
P-120	J-575	J-576	Steel	800	1077	100	FALSE	Open	49,368	1.14	2.39	2.22
P-121	J-576	J-577	Steel	800	429	100	FALSE	Open	44,616	1.03	0.79	1.84
P-122	J-431	PMP-057	Steel	1,600	27	100	FALSE	Open	159,236	0.92	0.02	0.66
P-123	PMP-057	FCV-Res058-In	Steel	1,600	30	100	TRUE	Open	159,236	0.92	0.02	0.66
P-124	FCV-Res058-In	Res-058	Steel	1,600	3493	100	FALSE	Open	159,236	0.92	2.32	0.66
P-125	PMP-056-2	FCV-J271-Out-2	Steel	1,400	28	100	TRUE	Open	63,750	0.48	0.01	0.23
P-126	FCV-J271-Out-2	J-331	Steel	1,400	2896	100	FALSE	Open	63,750	0.48	0.68	0.23
P-127	PMP-056-1	FCV-J271-Out-1	Steel	1,600	28	100	TRUE	Open	246,500	1.42	0.04	1.49
P-128	FCV-J271-Out-1	Res-057	Steel	1,600	2080	100	FALSE	Open	246,500	1.42	3.10	1.49
P-129	PMP-058	FCV-Res058-Out	Steel	1,600	37	100	TRUE	Open	105,754	0.61	0.01	0.31
P-130	FCV-Res058-Out	J-441	Steel	1,600	2350	100	TRUE	Open	105,754	0.61	0.73	0.31
P-131	PMP-059	FCV-Res080-In	Steel	1,400	28	100	TRUE	Open	56,843	0.43	0.01	0.19
P-132	FCV-Res080-In	Res-080	Steel	1,400	2471	100	FALSE	Open	56,843	0.43	0.47	0.19
P-133	PMP-080	FCV-Res081-In	Steel	1,000	33	100	TRUE	Open	34,590	0.51	0.01	0.39
P-134	FCV-Res081-In	Res-081	Steel	1,000	1270	100	FALSE	Open	34,590	0.51	0.49	0.39
P-136	PMP-065	FCV-CT065-Out	Steel	1,000	18	100	TRUE	Open	12,960	0.19	0.00	0.06
P-138	FCV-CT065-Out	J-209	Steel	1,000	68	100	FALSE	Open	12,960	0.19	0.00	0.06
P-140	PMP-073-2	FCV-Res073-Out-2	Steel	1,200	40	100	TRUE	Open	91,800	0.94	0.04	0.97
P-141	FCV-Res073-Out-2	Res-015	Steel	1,200	3391	100	TRUE	Open	91,800	0.94	3.29	0.97
P-142	PMP-073-1	FCV-Res073-Out-1	Steel	1,200	40	100	TRUE	Open	108,300	1.11	0.05	1.32
P-143	FCV-Res073-Out-1	Res-015	Steel	1,200	3412	100	TRUE	Open	108,300	1.11	4.50	1.32
P-144	CT-052	PMP-052-2	Steel	1200	1	100	FALSE	Open	52,800	0.54	0.00	0.37
P-145	PMP-066	FCV-CT066-Out	Steel	900	47	100	TRUE	Open	43,200	0.79	0.05	0.98
P-146	CT-052	PMP-052-1	Steel	1200	1	100	FALSE	Open	93,450	0.96	0.00	0.97
P-148	FCV-CT066-Out	J-206	Steel	900	105	100	TRUE	Open	43,200	0.79	0.10	0.98
P-151	J-311	J-312	Concrete	900	907	100	FALSE	Open	123,216	2.24	6.17	6.80
P-152	J-312	J-313	Concrete	900	1087	100	FALSE	Open	112,416	2.05	6.24	5.74
P-153	J-313	J-314	Concrete	900	695	100	FALSE	Open	101,616	1.85	3.31	4.76
P-154	PMP-095	FCV-ET113-In	Ductile Iron	500	24	110	TRUE	Open	9,936	0.59	0.02	0.94
P-155	FCV-ET113-In	ET-113	Ductile Iron	500	20	110	FALSE	Open	9,936	0.59	0.02	0.95
P-156	PMP-096	FCV-CT096-Out	Steel	1000	22	100	TRUE	Open	63,300	0.93	0.03	1.18
P-157	Res-016	PMP-016-2	Steel	900	1	100	FALSE	Open	10,800	0.20	0.00	0.07
P-158	FCV-CT096-Out	J-243	Steel	1000	1111	100	FALSE	Open	63,300	0.93	1.32	1.19
P-16	FCV-Res051-In-2	Res-051	Steel	800	29	100	FALSE	Open	103,326	2.38	0.25	8.71
P-160	J-601	J-602	Ductile Iron	700	2211	110	FALSE	Open	67,023	2.02	13.88	6.28
P-161	PMP-015	FCV-Res015-Out	Steel	1,100	10	100	TRUE	Open	64,697	0.79	0.01	0.77
P-162	J-240	J-241	Steel	1,100	143	100	TRUE	Open	22,481	0.27	0.02	0.11
P-163	FCV-Res015-Out	J-240	Steel	1100	2700	100	FALSE	Open	64,697	0.79	2.09	0.78
P-165	J-308	FCV-Res002-In-1	Steel	900	968	100	FALSE	Open	55,669	1.01	1.51	1.56
P-166	FCV-Res002-In-1	Res-002	Steel	900	23	100	TRUE	Open	55,669	1.01	0.04	1.56
P-167	J-483	FCV-Res023-In	Steel	900	47	100	FALSE	Open	98,064	1.78	0.21	4.46
P-169	FCV-Res023-In	Res-023	Steel	900	13	100	FALSE	Open	98,064	1.78	0.06	4.45
P-172	J-218-2	J-218-1	Steel	900	83	100	FALSE	Open	50,696	0.92	0.11	1.31
P-174	WTP-1	CWT-092	Steel	2500	1	100	FALSE	Open	232,600	0.55	0.00	0.15
P-175	Res-069	FCV-ET112-In	Steel	500	15	100	FALSE	Open	13,200	0.78	0.03	1.90
P-176	FCV-ET112-In	PMP-069	Steel	500	10	100	FALSE	Open	13,200	0.78	0.02	1.90
P-178	Res-020	FCV-Res026-In	Ductile Iron	700	1	110	FALSE	Open	41,384	1.24	0.00	2.53
P-179	PMP-092-1	J-261	Steel	800	413	100	TRUE	Open	30,800	0.71	0.38	0.93
P-18	PMP-043	Res-012	Steel	600	1,159	100	TRUE	Open	20,000	0.82	1.96	1.69
P-180	J-261	Res-001	Steel	800	1180	100	TRUE	Open	30,800	0.71	1.09	0.93
P-182	FCV-Res026-In	PMP-020	Ductile Iron	700	1	110	FALSE	Open	41,384	1.24	0.00	2.53
P-183	Res-032	FCV-Res091-In	Ductile Iron	400	1	110	FALSE	Open	9,677	0.89	0.00	2.68
P-184	J-304	J-308	Steel	900	806	100	FALSE	Open	255	0.00	0.00	0.00
P-185	J-304	J-305	Concrete	1350	714	100	FALSE	Open	179,750	1.45	1.36	1.90
P-186	FCV-Res091-In	PMP-032	Ductile Iron	400	1	110	FALSE	Open	9,677	0.89	0.00	2.68
P-187	Res-022	FCV-Res022-Out-1	Ductile Iron	500	1	110	FALSE	Open	21,581	1.27	0.00	4.02
P-188	FCV-Res022-Out-1	PMP-022-1	Ductile Iron	500	1	110	FALSE	Open	21,581	1.27	0.00	3.87
P-189	Res-022	FCV-Res022-Out-2	Ductile Iron	500	1	110	FALSE	Open	21,580	1.27	0.00	4.02
P-19	CWT-095	J-531	Steel	1400	293	100	FALSE	Open	250,445	1.88	0.86	2.94
P-190	FCV-Res022-Out-2	PMP-022-2	Ductile Iron	500	1	110	FALSE	Open	21,580	1.27	0.00	4.02
P-191	Res-027	FCV-Res029-In	Ductile Iron	500	1	110	FALSE	Open	4,879	0.29	0.00	0.30
P-193	CWT-092	J-252	Steel	700	96	100	FALSE	Open	96,344	2.90	1.41	14.66
P-194	CWT-092	J-253	Steel	700	96	100	FALSE	Open	105,336	3.17	1.66	17.30
P-195	J-252	J-253	Ductile Iron	900	70	110	FALSE	Open	96,344	1.75	0.25	3.61
P-196	FCV-Res029-In	PMP-027	Ductile Iron	500	1	110	FALSE	Open	4,879	0.29	0.00	0.30
P-197	Res-025	FCV-Res027-In	Ductile Iron	600	1	110	FALSE	Open	28,800	1.18	0.00	2.83
P-198	FCV-Res027-In	PMP-025	Ductile Iron	600	1	110	FALSE	Open	28,800	1.18	0.00	2.83
P-2	J-520	Res-094	Ductile Iron	500	32	110	FALSE	Open	28,414	1.67	0.21	6.59
P-200	Res-022	FCV-Res022-Out-3	Ductile Iron	600	1	110	FALSE	Open	15,300	0.63	0.00	0.89
P-201	J-253	J-251	Steel	900	486	100	FALSE	Open	86,185	1.57	1.70	3.51
P-202	J-251	J-256	Steel	900	2,734	100	FALSE	Open	86,185	1.57	9.59	3.51
P-203	J-253	J-254	Ductile Iron	900	1289	110	FALSE	Open	115,495	2.10	6.52	5.05
P-204	J-254	J-255	Steel	900	873	100	FALSE	Open	71,480	1.30	2.17	2.48
P-205	J-255	J-256	Steel	900	1053	100	FALSE	Open	71,480	1.30	2.61	2.48
P-206	FCV-Res022-Out-3	PMP-022-3	Ductile Iron	600	1	110	FALSE	Open	15,300	0.63	0.00	0.89
P-207	Res-072	FCV-Res072-Out	Steel	1200	1	100	FALSE	Open	30,540	0.31	0.00	0.15
P-210	PMP-001-1	J-341	Steel	900	924	100	TRUE	Open	76,800	1.40	2.62	2.83
P-211	FCV-Res072-Out	PMP-072	Steel	1200	1	100	FALSE	Open	30,540	0.31	0.00	0.15
P-212	J-342	Res-014	Steel	900	108	100	TRUE	Open	40,368	0.73	0.09	0.86

Section 2: Transmission Network Model

Table 2: Pipe Elements

Label	From Node	To Node	Material	Diameter (mm)	Length (m)	Hazen-Williams C	Check Valve?	Control Status	Discharge (m3/day)	Velocity (m/s)	Pipe Headloss (m)	Headloss Gradient (m/km)
P-214	Res-037	FCV-Res072-In	Steel	1400	1	100	FALSE	Open	51,449	0.39	0.00	0.15
P-215	J-361	Res-014	Concrete	700	108	100	TRUE	Open	20,991	0.63	0.09	0.87
P-216	J-361	J-342	Ductile Iron	900	8	110	FALSE	Open	17,460	0.32	0.00	0.15
P-217	J-341	J-351	Steel	900	295	100	FALSE	Open	53,891	0.98	0.43	1.47
P-218	FCV-Res072-In	PMP-037	Steel	1400	1	100	FALSE	Open	51,449	0.39	0.00	0.15
P-219	Res-074	FCV-Res075-In	Ductile Iron	900	1	110	FALSE	Open	14,680	0.27	0.00	0.15
P-22	CWT-097	J-540	Concrete	1200	426	100	FALSE	Open	223,110	2.28	2.14	5.03
P-220	FCV-Res075-In	PMP-074	Ductile Iron	900	1	110	FALSE	Open	14,680	0.27	0.00	0.00
P-221	J-352	Res-018	Ductile Iron	400	232	110	FALSE	Open	10,000	0.92	0.66	2.83
P-222	Res-024	FCV-Res032-In	Ductile Iron	800	1	110	FALSE	Open	28,905	0.67	0.00	0.74
P-224	PMP-008	Res-018	Ductile Iron	500	1829	110	TRUE	Open	1,980	0.12	0.09	0.05
P-226	J-381	J-371	Steel	1,200	5,015	100	FALSE	Open	24,540	0.25	0.42	0.08
P-227	J-381	J-382	Ductile Iron	600	2,436	110	FALSE	Open	4,570	0.19	0.22	0.09
P-228	FCV-Res032-In	PMP-024	Ductile Iron	800	1	110	FALSE	Open	28,905	0.67	0.00	0.74
P-229	J-382	J-392	Ductile Iron	600	2,048	110	FALSE	Open	4,570	0.19	0.19	0.09
P-23	J-540	J-541	Steel	1,200	2,387	100	FALSE	Open	219,110	2.24	11.61	4.86
P-231	BS-017	J-490	Steel	1,250	27	100	FALSE	Open	55,000	0.52	0.01	0.31
P-232	J-392	J-393	Ductile Iron	600	601	110	FALSE	Open	17,595	0.72	0.67	1.12
P-233	PMP-074	Res-075	Ductile Iron	900	1,406	110	TRUE	Open	14,680	0.27	0.16	0.11
P-235	PMP-014-1	J-370	Steel	900	1,145	100	TRUE	Open	20,599	0.37	0.28	0.25
P-236	J-370	J-371	Steel	900	714	100	FALSE	Open	20,599	0.37	0.18	0.25
P-237	J-371	J-372	Steel	1,200	2,340	100	FALSE	Open	45,139	0.46	0.61	0.26
P-238	J-992	Res-010	Ductile Iron	700	1,465	110	FALSE	Open	48,470	1.46	5.04	3.44
P-239	J-372	J-393	Steel	400	9	100	FALSE	Open	13,204	1.22	0.05	5.64
P-24	J-473	J-481	Steel	2,200	932	100	FALSE	Open	239,751	0.73	0.28	0.30
P-240	J-393	J-394	Steel	400	39	100	FALSE	Open	10,800	0.99	0.15	3.89
P-241	Res-002	FCV-Res010-In	Ductile Iron	900	22	110	FALSE	Open	48,470	0.88	0.02	1.01
P-242	FCV-Res010-In	PMP-002	Ductile Iron	900	22	110	FALSE	Open	48,470	0.88	0.02	1.01
P-243	Res-028	FCV-ET033-In	Ductile Iron	150	1	110	FALSE	Open	3,800	2.49	0.06	55.96
P-244	FCV-ET033-In	PMP-028	Ductile Iron	150	1	110	FALSE	Open	3,800	2.49	0.06	55.96
P-245	PMP-020	Res-026	Ductile Iron	700	562	110	TRUE	Open	41,384	1.24	1.44	2.57
P-246	Res-038	FCV-Res082-In	Ductile Iron	700	1	110	FALSE	Open	11,971	0.36	0.00	0.30
P-247	PMP-026	Res-028	Ductile Iron	400	1,185	110	TRUE	Open	10,971	1.01	3.98	3.36
P-248	FCV-Res082-In	PMP-038	Ductile Iron	700	1	110	FALSE	Open	11,971	0.36	0.00	0.30
P-249	PMP-028	ET-033	Ductile Iron	150	177	110	TRUE	Open	3,800	2.49	9.91	55.97
P-25	J-990	WTP-1	Steel	1,000	3,670	100	FALSE	Open	37,562	0.55	1.65	0.45
P-250	Res-071	FCV-Res094-In	Ductile Iron	700	1	110	FALSE	Open	28,414	0.85	0.00	1.34
P-251	FCV-Res094-In	PMP-071	Ductile Iron	700	1	110	FALSE	Open	28,414	0.85	0.00	1.34
P-252	J-532	FCV-BPT076-In	Steel	800	22	100	FALSE	Open	103,326	2.38	0.19	8.71
P-253	PMP-022-1	J-401	Ductile Iron	500	653	110	TRUE	Open	21,581	1.27	2.59	3.96
P-254	J-401	Res-024	Ductile Iron	500	2,994	110	FALSE	Open	21,567	1.27	11.85	3.96
P-255	FCV-BPT076-In	BPT-076	Steel	800	41	100	FALSE	Open	103,326	2.38	0.36	8.71
P-256	PMP-022-2	J-411	Ductile Iron	500	657	110	TRUE	Open	21,580	1.27	2.60	3.96
P-257	J-411	Res-024	Ductile Iron	500	2,987	110	FALSE	Open	21,594	1.27	11.85	3.97
P-258	J-401	J-411	Ductile Iron	500	8	110	FALSE	Open	14	0.00	0.00	0.00
P-26	J-254	FCV-Res004-In	Steel	900	35	100	FALSE	Open	44,015	0.80	0.04	1.01
P-261	PMP-052-1	FCV-Res052-Out-1	Steel	1,200	29	100	TRUE	Open	93,450	0.96	0.03	1.00
P-262	FCV-Res052-Out-1	Res-016	Steel	1,200	1,390	100	TRUE	Open	93,450	0.96	1.39	1.00
P-263	CWT-097	FCV-Res071-In	Ductile Iron	700	1	110	FALSE	Open	65,492	1.97	0.01	6.10
P-264	PMP-032	Res-091	Ductile Iron	500	400	110	TRUE	Open	9,677	0.57	0.36	0.90
P-265	FCV-Res071-In	Res-071	Ductile Iron	700	1	110	FALSE	Open	65,492	1.97	0.01	5.95
P-266	Res-008	FCV-Res008-Out	Ductile Iron	500	1	110	FALSE	Open	1,980	0.12	0.00	0.00
P-267	FCV-Res008-Out	PMP-008	Ductile Iron	500	1	110	FALSE	Open	1,980	0.12	0.00	0.15
P-268	CWT-093	FCV-Res034-In	Ductile Iron	400	1	110	FALSE	Open	12,787	1.18	0.00	4.46
P-269	PMP-022-3	Res-038	Ductile Iron	600	5,016	110	TRUE	Open	15,300	0.63	4.32	0.86
P-27	FCV-Res004-In	Res-004	Steel	900	13	100	TRUE	Open	44,015	0.80	0.01	1.01
P-270	FCV-Res034-In	PMP-093	Ductile Iron	400	1	110	FALSE	Open	12,787	1.18	0.00	4.46
P-271	Res-043	FCV-Res012-In	Steel	600	1	100	FALSE	Open	20,000	0.82	0.00	1.64
P-272	FCV-Res012-In	PMP-043	Steel	600	1	100	FALSE	Open	20,000	0.82	0.00	1.64
P-273	Res-036	FCV-Res063-In	Steel	800	1	100	FALSE	Open	44,354	1.02	0.00	1.79
P-274	FCV-Res063-In	PMP-036	Steel	800	1	100	FALSE	Open	44,354	1.02	0.00	1.86
P-275	CWT-093	J-271	Concrete	1,600	71	100	FALSE	Open	376,250	2.17	0.23	3.26
P-276	CWT-092	FCV-Res001-In-1	Steel	800	1	100	FALSE	Open	30,800	0.71	0.00	0.89
P-277	FCV-Res001-In-1	PMP-092-1	Steel	800	1	100	FALSE	Open	30,800	0.71	0.00	0.97
P-280	CWT-092	FCV-Res003-In	Steel	900	1,633	100	TRUE	Open	3,880	0.07	0.02	0.01
P-281	FCV-Res003-In	Res-003	Steel	900	9	100	TRUE	Open	3,880	0.07	0.00	0.01
P-282	J-577	J-593	Steel	900	405	100	FALSE	Open	42,542	0.77	0.38	0.95
P-283	J-593	J-578	Steel	900	1,721	100	FALSE	Open	99,409	1.81	7.86	4.57
P-284	J-582	J-593	Steel	900	954	100	FALSE	Open	70,000	1.27	2.28	2.39
P-287	CWT-093	J-300	Concrete	1,850	4,355	100	FALSE	Open	226,089	0.97	2.72	0.63
P-288	J-300	J-301	Steel	1,850	891	100	FALSE	Open	204,619	0.88	0.46	0.52
P-290	J-301	J-302	Concrete	1,850	5,647	100	FALSE	Open	204,619	0.88	2.94	0.52
P-296	Res-001	FCV-Res001-Out-1	Steel	900	1	100	FALSE	Open	76,800	1.40	0.00	2.83
P-297	FCV-Res001-Out-1	PMP-001-1	Steel	900	1	100	FALSE	Open	76,800	1.40	0.00	2.83
P-298	J-633	J-632	Steel	1,000	368	100	FALSE	Open	7,920	0.12	0.01	0.03
P-299	Res-001	FCV-Res001-Out-2	Concrete	700	1	100	FALSE	Open	47,955	1.44	0.00	4.02
P-3	J-PMP-024	J-420	Ductile Iron	300	568	110	TRUE	Open	6,475	1.06	2.92	5.13
P-30	J-351	FCV-Res009-In	Steel	900	35	100	FALSE	Open	43,891	0.80	0.04	1.00
P-300	FCV-Res001-Out-2	PMP-001-2	Concrete	700	1	100	FALSE	Open	47,955	1.44	0.00	4.02
P-301	BS-114	J-321	Ductile Iron	500	192	110	TRUE	Open	33,600	1.98	1.73	9.00

Section 2: Transmission Network Model
Table 2: Pipe Elements

Label	From Node	To Node	Material	Diameter (mm)	Length (m)	Hazen-Williams C	Check Valve?	Control Status	Discharge (m3/day)	Velocity (m/s)	Pipe Headloss (m)	Headloss Gradient (m/km)
P-302	J-631	J-990	Steel	1,000	985	100	TRUE	Open	37,562	0.55	0.44	0.45
P-303	Res-014	FCV-Res014-Out-2	Ductile Iron	600	1	110	FALSE	Open	40,760	1.67	0.01	5.36
P-304	CWT-093	J-321	Concrete	1,850	6,589	100	FALSE	Open	214,140	0.92	3.73	0.57
P-305	J-321	J-322	Concrete	1,850	2,403	100	FALSE	Open	247,740	1.07	1.78	0.74
P-306	FCV-Res014-Out-2	PMP-014-2	Ductile Iron	600	1	110	FALSE	Open	40,760	1.67	0.01	5.21
P-307	Res-014	FCV-Res014-Out-1	Steel	900	1	100	FALSE	Open	20,599	0.37	0.00	0.30
P-308	FCV-Res014-Out-1	PMP-014-1	Steel	900	1	100	FALSE	Open	20,599	0.37	0.00	0.15
P-31	FCV-Res009-In	Res-009	Steel	900	16	100	FALSE	Open	43,891	0.80	0.02	1.00
P-310	J-281	J-282	Steel	1,200	2,660	100	FALSE	Open	66,000	0.68	1.40	0.53
P-311	J-283	J-282	Steel	1,200	2,889	100	FALSE	Open	2,549	0.03	0.00	0.00
P-312	J-291	J-283	Steel	1,200	465	100	TRUE	Open	2,549	0.03	0.00	0.00
P-313	CWT-092	FCV-CWT092-Out	Steel	1,000	1	100	FALSE	Open	30,800	0.45	0.00	0.30
P-314	FCV-CWT092-Out	PMP-092-2	Steel	1,000	1	100	FALSE	Open	30,800	0.45	0.00	0.37
P-315	PMP-013	J-291	Steel	1,100	1,126	100	TRUE	Open	55,297	0.67	0.65	0.58
P-316	J-291	J-300	Steel	1,100	1,260	100	FALSE	Open	52,748	0.64	0.67	0.53
P-317	J-490	FCV-Res021-In-4	Steel	1,250	1,654	100	TRUE	Open	25,890	0.24	0.13	0.08
P-318	FCV-Res021-In-4	Res-021	Steel	1,250	9	100	FALSE	Open	25,890	0.24	0.00	0.08
P-319	Res-068	FCV-Res068-Out	Ductile Iron	700	1	110	FALSE	Open	7,840	0.24	0.00	0.15
P-320	FCV-Res068-Out	PMP-068-1	Ductile Iron	700	1	110	FALSE	Open	7,840	0.24	0.00	0.07
P-322	CT-096	PMP-096	Steel	1,000	1	100	FALSE	Open	63,300	0.93	0.00	1.19
P-328	Res-063	FCV-Res063-Out	Ductile Iron	600	10	110	FALSE	Open	44,354	1.82	0.06	6.19
P-329	J-243	J-242	Steel	900	649	100	FALSE	Open	1,734	0.03	0.00	0.00
P-330	J-243	J-244	Steel	900	913	100	FALSE	Open	55,950	1.02	1.44	1.58
P-331	FCV-Res063-Out	J-611	Ductile Iron	600	2,841	110	FALSE	Open	44,354	1.82	17.59	6.19
P-333	FCV-Res051-In-1	Res-051	Steel	300	6	100	FALSE	Open	10,000	1.64	0.08	13.69
P-334	J-314	FCV-Res016-In	Concrete	900	1,177	100	FALSE	Open	80,362	1.46	3.63	3.08
P-335	FCV-Res016-In	Res-016	Concrete	900	6	100	FALSE	Open	80,362	1.46	0.02	3.08
P-336	J-305	FCV-Res006-In-2	Ductile Iron	700	1,024	110	FALSE	Open	7,353	0.22	0.11	0.10
P-337	Res-015	PMP-015	Steel	1,100	1	100	FALSE	Open	64,697	0.79	0.00	0.74
P-338	FCV-Res006-In-2	Res-006	Ductile Iron	700	8	110	TRUE	Open	7,353	0.22	0.00	0.10
P-347	PMP-069	ET-112	Steel	500	83	100	TRUE	Open	13,200	0.78	0.16	1.90
P-348	Res-073	PMP-073-1	Steel	1,200	1	100	FALSE	Open	108,300	1.11	0.00	1.34
P-350	Res-073	PMP-073-2	Steel	1,200	1	100	FALSE	Open	91,800	0.94	0.00	0.97
P-351	J-256	FCV-Res005-In	Steel	900	72	100	FALSE	Open	67,180	1.22	0.16	2.21
P-352	FCV-Res005-In	Res-005	Steel	900	12	100	FALSE	Open	67,180	1.22	0.03	2.21
P-357	PMP-068-1	J-202	Ductile Iron	700	1,942	110	TRUE	Open	7,840	0.24	0.23	0.12
P-358	J-307	FCV-Res031-In	Concrete	1,250	170	100	FALSE	Open	132,653	1.25	0.27	1.57
P-359	FCV-Res031-In	Res-031	Concrete	1,250	9	100	TRUE	Open	132,653	1.25	0.01	1.57
P-360	CT-066	PMP-066	Steel	900	1	100	FALSE	Open	43,200	0.79	0.00	0.97
P-361	BPT-076	J-533	Steel	800	86	100	FALSE	Open	103,326	2.38	0.75	8.71
P-367	CT-065	PMP-065	Steel	1,000	1	100	FALSE	Open	12,960	0.19	0.00	0.07
P-369	Res-015	J-221	Steel	1,100	4,664	100	FALSE	Open	52,899	0.64	2.49	0.53
P-370	J-221	J-212	Steel	900	5,261	100	FALSE	Open	52,899	0.96	7.47	1.42
P-371	FCV-J-522-In-2	J-522	Steel	250	9	100	FALSE	Open	4,000	0.94	0.05	6.10
P-372	J-201	J-202	Steel	1,400	830	100	FALSE	Open	131,074	0.99	0.74	0.89
P-373	J-202	J-203	Steel	1,400	661	100	FALSE	Open	138,914	1.04	0.65	0.99
P-374	J-203	J-204	Steel	1,400	2,134	100	FALSE	Open	110,238	0.83	1.37	0.64
P-375	J-204	J-206	Steel	1,400	1,230	100	FALSE	Open	68,022	0.51	0.32	0.26
P-376	J-206	J-207	Steel	1,400	488	100	FALSE	Open	111,222	0.84	0.32	0.65
P-377	J-207	J-208	Steel	1,100	1,139	100	FALSE	Open	82,591	1.01	1.39	1.22
P-378	J-208	J-209	Steel	1,100	1,011	100	FALSE	Open	82,591	1.01	1.23	1.22
P-379	J-209	J-210	Steel	1,100	197	100	FALSE	Open	95,551	1.16	0.31	1.60
P-38	J-442	FCV-Res022-In-1	Steel	1,200	3,761	100	TRUE	Open	6,526	0.07	0.03	0.01
P-380	J-210	J-211	Steel	1,100	1,248	100	FALSE	Open	66,920	0.82	1.03	0.83
P-381	J-211	J-212	Steel	1,100	1,206	100	FALSE	Open	38,289	0.47	0.35	0.29
P-382	J-212	J-213	Concrete	900	121	100	FALSE	Open	91,188	1.66	0.47	3.89
P-383	J-213	J-214	Concrete	900	803	100	FALSE	Open	62,557	1.14	1.56	1.94
P-384	J-214	J-215	Concrete	900	795	100	FALSE	Open	33,926	0.62	0.50	0.62
P-385	J-521	FCV-J522-In-1	Steel	300	1,269	100	FALSE	Open	6,000	0.98	6.75	5.32
P-386	FCV-J522-In-1	J-522	Steel	300	17	100	FALSE	Open	6,000	0.98	0.09	5.31
P-387	J-219	J-218-2	Concrete	900	8	100	FALSE	Open	50,696	0.92	0.01	1.31
P-388	PMP-093	Res-034	Ductile Iron	400	2,129	110	TRUE	Open	12,787	1.18	9.49	4.46
P-389	J-219	J-231	Steel	900	8	100	FALSE	Open	34,615	0.63	0.01	0.65
P-39	FCV-Res022-In-1	Res-022	Steel	1,200	21	100	TRUE	Open	6,526	0.07	0.00	0.01
P-393	Res-016	FCV-Res016-Out	Concrete	1,250	14	100	FALSE	Open	178,207	1.68	0.04	2.72
P-394	FCV-Res016-Out	J-219	Concrete	1,250	3,843	100	FALSE	Open	178,207	1.68	10.45	2.72
P-395	J-219	FCV-Res036-In	Steel	900	4,994	100	FALSE	Open	92,896	1.69	20.12	4.03
P-396	FCV-Res036-In	Res-036	Steel	900	18	100	FALSE	Open	92,896	1.69	0.07	4.03
P-397	J-331	Res-059	Steel	1,400	307	100	FALSE	Open	63,750	0.48	0.07	0.23
P-398	Res-059	PMP-059	Steel	1,400	1	100	FALSE	Open	56,843	0.43	0.00	0.15
P-4	PMP-071	J-520	Ductile Iron	700	1,705	110	TRUE	Open	28,414	0.85	2.18	1.28
P-40	J-372	FCV-Res022-In-3	Steel	1,200	61	100	FALSE	Open	31,935	0.33	0.01	0.14
P-400	Res-080	PMP-080	Steel	1,000	1	100	FALSE	Open	34,590	0.51	0.00	0.45
P-401	Res-040	FCV-Res040-Out-1	Steel	1,200	14	100	FALSE	Open	3,327	0.03	0.00	0.00
P-402	FCV-Res040-Out-1	J-561	Steel	1,200	67	100	FALSE	Open	3,327	0.03	0.00	0.00
P-403	J-561	J-562	Steel	1,000	1,090	100	FALSE	Open	3,327	0.05	0.01	0.01
P-404	Res-057	J-431	Steel	1,600	46	100	FALSE	Open	182,132	1.05	0.04	0.85
P-405	J-554	FCV-J554-Out	Steel	900	7	100	FALSE	Open	70,000	1.27	0.02	2.38
P-408	Res-058	PMP-058	Steel	1,600	1	100	FALSE	Open	105,754	0.61	0.00	0.30
P-41	FCV-Res022-In-3	Res-022	Steel	1,200	31	100	FALSE	Open	31,935	0.33	0.00	0.14

Section 2: Transmission Network Model
Table 2: Pipe Elements

Label	From Node	To Node	Material	Diameter (mm)	Length (m)	Hazen-Williams C	Check Valve?	Control Status	Discharge (m3/day)	Velocity (m/s)	Pipe Headloss (m)	Headloss Gradient (m/km)
P-410	J-441	J-442	Steel	1,200	2,842	100	TRUE	Open	6,526	0.07	0.02	0.01
P-414	PMP-037	Res-072	Steel	1,400	3217	100	TRUE	Open	51,449	0.39	0.50	0.16
P-416	PMP-072	Res-038	Steel	1,200	1,109	100	TRUE	Open	30,540	0.31	0.14	0.13
P-418	PMP-038	Res-082	Ductile Iron	700	1,941	110	TRUE	Open	11,971	0.36	0.50	0.26
P-422	PMP-014-2	J-391	Ductile Iron	600	739	110	TRUE	Open	40,760	1.67	3.91	5.29
P-423	J-391	J-392	Ductile Iron	600	1605	110	FALSE	Open	29,960	1.23	4.80	2.99
P-424	J-215	J-216	Concrete	900	707	100	FALSE	Open	5,247	0.10	0.01	0.02
P-425	J-217	J-216	Concrete	900	802	100	FALSE	Open	23,384	0.43	0.25	0.31
P-426	J-231	J-217-2	Ductile Iron	1200	353	110	FALSE	Open	107,740	1.10	0.39	1.09
P-427	J-217-2	J-217-1	Ductile Iron	1,000	905	110	FALSE	Open	65,524	0.97	0.96	1.06
P-428	J-217-1	J-217	Ductile Iron	900	234	110	FALSE	Open	65,524	1.19	0.41	1.77
P-429	Res-015	J-200	Steel	1200	850	100	FALSE	Open	65,537	0.67	0.44	0.52
P-430	J-200	J-201	Steel	1,400	2029	100	FALSE	Open	131,074	0.99	1.80	0.89
P-431	Res-015	J-200	Steel	1,200	850	100	FALSE	Open	65,537	0.67	0.44	0.52
P-432	J-531	J-532	Steel	800	3827	100	FALSE	Open	103,326	2.38	33.33	8.71
P-433	J-540	FCV-J-522-In-2	Steel	250	5,535	100	FALSE	Open	4,000	0.94	33.76	6.10
P-434	CWT-097	J-521	Ductile Iron	300	4,666	110	FALSE	Open	6,000	0.98	20.80	4.46
P-435	J-306	J-307	Concrete	1250	3,045	100	FALSE	Open	172,397	1.63	7.78	2.56
P-436	J-305	J-306	Concrete	1,350	2,634	100	FALSE	Open	172,397	1.39	4.63	1.76
P-437	Res-011	J-571	Steel	800	431	100	FALSE	Open	85,829	1.98	2.66	6.18
P-438	FCV-J554-Out	J-581	Steel	900	2398	100	FALSE	Open	70,000	1.27	5.72	2.39
P-439	PMP-092-2	J-303	Steel	900	1,559	100	TRUE	Open	30,800	0.56	0.81	0.52
P-44	J-393	FCV-Res022-In-2	Ductile Iron	600	48	110	FALSE	Open	20,000	0.82	0.07	1.42
P-440	J-303	J-308	Steel	900	2787	100	TRUE	Open	55,414	1.01	4.31	1.55
P-441	Res-056	J-281	Steel	1200	132	100	TRUE	Open	66,000	0.68	0.07	0.53
P-444	Res-031	J-311	Concrete	900	1350	100	FALSE	Open	130,128	2.37	10.15	7.52
P-445	J-592	J-593-1	Steel	1200	1,821	100	FALSE	Open	7,632	0.08	0.02	0.01
P-446	Res-019	J-591	Steel	1,200	2,282	100	FALSE	Open	7,632	0.08	0.02	0.01
P-447	J-522	FCV-Res051-In-1	Steel	300	7,632	100	FALSE	Open	10,000	1.64	104.52	13.69
P-448	J-541	J-541-2	Steel	1200	434	100	FALSE	Open	219,110	2.24	2.11	4.86
P-449	J-541-2	J-542	Steel	1,200	478	100	FALSE	Open	196,346	2.01	1.90	3.97
P-45	J-581	J-582	Steel	900	33	100	FALSE	Open	70,000	1.27	0.08	2.39
P-450	CWT-097	J-551	Concrete	1250	3267	100	FALSE	Open	243,917	2.30	15.88	4.86
P-451	J-533	FCV-Res051-In-2	Steel	800	9,235	100	FALSE	Open	103,326	2.38	80.43	8.71
P-452	J-541-2	J-551	Ductile Iron	600	13	110	FALSE	Open	22,763	0.93	0.02	1.80
P-453	J-542	J-544	Steel	1200	1054	100	FALSE	Open	166,346	1.70	3.08	2.92
P-454	J-544	J-545	Steel	1,200	1,156	100	FALSE	Open	131,707	1.35	2.19	1.89
P-455	J-545	J-546	Steel	1,200	699	100	FALSE	Open	121,838	1.25	1.15	1.64
P-456	J-546	J-553	Steel	1,200	240	100	FALSE	Open	82,323	0.84	0.19	0.79
P-457	J-551	J-552	Concrete	1,200	1519	100	FALSE	Open	177,439	1.82	5.00	3.29
P-458	J-552	J-553	Concrete	1,200	2,090	100	FALSE	Open	122,836	1.26	3.48	1.66
P-459	J-544	J-552	Ductile Iron	600	12	110	FALSE	Open	34,640	1.42	0.05	3.92
P-460	Res-004	FCV-Res004-Out	Steel	1000	12	100	FALSE	Open	65,135	0.96	0.01	1.25
P-461	FCV-Res004-Out	J-246	Steel	1,000	1897	100	FALSE	Open	65,135	0.96	2.37	1.25
P-462	J-553	J-553-1	Steel	1,200	1,835	100	FALSE	Open	125,000	1.28	3.16	1.72
P-463	J-553-1	J-554	Steel	1,200	999	100	FALSE	Open	125,000	1.28	1.72	1.72
P-464	J-543	J-543-1	Steel	1,400	1809	100	FALSE	Open	147,119	1.11	1.99	1.10
P-465	J-543-1	J-543-2	Ductile Iron	1,400	1,039	110	FALSE	Open	116,808	0.88	0.62	0.60
P-467	J-244	J-244-1	Steel	900	1,149	100	FALSE	Open	12,059	0.22	0.11	0.09
P-468	J-245	J-244-1	Steel	900	1,192	100	FALSE	Open	31,832	0.58	0.66	0.55
P-469	J-245	J-245-1	Steel	900	659	100	FALSE	Open	45,558	0.83	0.71	1.08
P-470	J-245-1	J-245-2	Steel	900	653	100	FALSE	Open	31,216	0.57	0.35	0.53
P-471	J-246	J-245-2	Steel	900	661	100	FALSE	Open	12,675	0.23	0.07	0.10
P-472	J-246	J-246-1	Steel	900	582	100	FALSE	Open	29,996	0.55	0.29	0.50
P-473	J-246-1	J-247	Steel	900	695	100	FALSE	Open	15,654	0.28	0.10	0.15
P-474	J-247	J-247-1	Steel	900	1031	100	FALSE	Open	33,058	0.60	0.61	0.59
P-475	J-247-2	J-247-1	Steel	900	174	100	FALSE	Open	10,920	0.20	0.01	0.08
P-476	J-248	J-247-2	Steel	900	578	100	FALSE	Open	25,262	0.46	0.21	0.36
P-477	Res-013	FCV-Res013-Out	Steel	1100	14	100	FALSE	Open	19,763	0.24	0.00	0.09
P-478	FCV-Res013-Out	J-241	Steel	1,100	1722	100	FALSE	Open	19,763	0.24	0.15	0.09
P-479	Res-003	FCV-Res003-Out	Steel	1,100	8	100	FALSE	Open	77,390	0.94	0.01	1.08
P-48	J-591	J-592	Steel	1,200	26	100	FALSE	Open	7,632	0.08	0.00	0.01
P-480	FCV-Res003-Out	J-245	Steel	1,100	1281	100	FALSE	Open	77,390	0.94	1.38	1.08
P-481	Res-005	FCV-Res005-Out	Steel	1,100	7	100	FALSE	Open	89,980	1.10	0.01	1.43
P-482	CWT-099	J-451	Ductile Iron	1,600	2117	110	FALSE	Open	146,207	0.84	1.00	0.47
P-483	FCV-Res005-Out	J-247	Steel	1,100	1,937	100	FALSE	Open	89,980	1.10	2.77	1.43
P-484	Res-006	FCV-Res006-Out	Steel	1,100	7	100	FALSE	Open	97,838	1.19	0.01	1.66
P-485	FCV-Res006-Out	J-248	Steel	1,100	1892	100	FALSE	Open	97,838	1.19	3.16	1.67
P-486	CWT-099	J-461	Ductile Iron	1,600	2,118	110	FALSE	Open	133,693	0.77	0.85	0.40
P-487	PMP-016-2	FCV-Res051-In	Steel	900	8	100	FALSE	Open	10,800	0.20	0.00	0.07
P-488	Res-013	FCV-Res013-Out-1	Steel	1200	1	100	FALSE	Open	55,297	0.57	0.00	0.37
P-489	FCV-Res013-Out-1	PMP-013	Steel	1,200	1	100	FALSE	Open	55,297	0.57	0.00	0.37
P-49	FCV-Res022-In-2	Res-022	Ductile Iron	600	42	110	TRUE	Open	20,000	0.82	0.06	1.42
P-490	PMP-001-2	J-361	Concrete	700	2933	100	TRUE	Open	47,955	1.44	11.81	4.03
P-491	J-481	FCV-Res021-In-2	Steel	1000	16	100	FALSE	Open	4,500	0.07	0.00	0.01
P-492	FCV-Res021-In-2	J-PMP-021-2	Steel	1,000	466	100	FALSE	Open	4,500	0.07	0.00	0.01
P-493	J-491	FCV-Res021-In-1	Steel	1,200	16	100	FALSE	Open	5,577	0.06	0.00	0.01
P-494	FCV-Res021-In-1	J-PMP-021-1	Steel	1,200	463	100	FALSE	Open	5,577	0.06	0.00	0.01
P-495	FCV-Res051-In	J-PMP-016-2	Steel	900	21	100	FALSE	Open	10,800	0.20	0.00	0.07
P-496	Res-016	FCV-016-053	Steel	1200	1	100	FALSE	Open	20,325	0.21	0.00	0.07

Section 2: Transmission Network Model
Table 2: Pipe Elements

Label	From Node	To Node	Material	Diameter (mm)	Length (m)	Hazen-Williams C	Check Valve?	Control Status	Discharge (m3/day)	Velocity (m/s)	Pipe Headloss (m)	Headloss Gradient (m/km)
P-497	FCV-016-053	Res-053	Steel	1,200	1	100	FALSE	Open	20,325	0.21	0.00	0.07
P-50	J-473	FCV-Res041-In	Ductile Iron	700	780	110	FALSE	Open	16,330	0.49	0.36	0.46
P-500	J-452	FCV-Res074-In-1	Steel	900	15	100	FALSE	Open	23,819	0.43	0.00	0.32
P-501	FCV-Res074-In-1	Res-074	Steel	900	726	100	TRUE	Open	23,819	0.43	0.24	0.32
P-504	Res-051	FCV-Res051-Out	Steel	1100	5	100	FALSE	Open	124,126	1.51	0.01	2.59
P-505	FCV-Res051-Out	J-601	Steel	1,100	1445	100	FALSE	Open	124,126	1.51	3.75	2.59
P-506	J-562	FCV-Res021-In-5	Steel	1,000	852	100	FALSE	Open	3,327	0.05	0.00	0.01
P-507	FCV-Res021-In-5	Res-021	Steel	1,000	8	100	FALSE	Open	3,327	0.05	0.00	0.00
P-51	FCV-Res041-In	Res-041	Ductile Iron	700	23	110	FALSE	Open	16,330	0.49	0.01	0.46
P-526	J-256	FCV-Res006-In-1	Steel	900	1363	100	TRUE	Open	90,485	1.65	5.23	3.84
P-527	FCV-Res006-In-1	Res-006	Steel	900	11	100	TRUE	Open	90,485	1.65	0.04	3.84
P-53	PMP-019	J-PMP-019	Steel	1200	24	100	TRUE	Open	0	0.00	0.00	0.00
P-530	J-441	FCV-Res037-In	Steel	1,200	810	100	FALSE	Open	99,228	1.02	0.91	1.12
P-531	FCV-Res037-In	Res-037	Steel	1,200	5	100	FALSE	Open	99,228	1.02	0.01	1.13
P-532	J-554	FCV-BS018-In	Steel	1,250	13	100	FALSE	Open	55,000	0.52	0.00	0.31
P-533	J-490	FCV-J490-Out	Steel	1,200	9	100	FALSE	Open	29,110	0.30	0.00	0.12
P-534	FCV-J490-Out	J-381	Steel	1,200	637	100	FALSE	Open	29,110	0.30	0.07	0.12
P-538	J-241	J-241-1	Steel	1,100	535	100	FALSE	Open	42,244	0.51	0.19	0.35
P-539	J-241-1	J-242	Steel	1,100	493	100	FALSE	Open	42,244	0.51	0.17	0.35
P-560	PMP-052-2	FCV-Res052-Out-2	Steel	1,200	25	100	TRUE	Open	52,800	0.54	0.01	0.35
P-561	FCV-Res052-Out-2	Res-053	Steel	1,200	1,044	100	FALSE	Open	52,800	0.54	0.36	0.35
P-566	J-593-1	FCV-Res007-In-2	Steel	1,200	146	100	FALSE	Open	7,632	0.08	0.00	0.01
P-567	FCV-Res007-In-2	Res-007	Steel	1200	67	100	FALSE	Open	7,632	0.08	0.00	0.01
P-57	J-271	FCV-Res056-In	Concrete	1600	27	100	TRUE	Open	66,000	0.38	0.00	0.13
P-570	J-543-2	FCV-Res019-In	Ductile Iron	1200	1521	110	FALSE	Open	116,808	1.20	1.93	1.27
P-571	FCV-Res019-In	Res-019	Ductile Iron	1,200	28	110	FALSE	Open	116,808	1.20	0.04	1.27
P-572	J-422	FCV-Res030-In	Ductile Iron	300	1304	110	TRUE	Open	4,657	0.76	3.63	2.79
P-574	J-602	FCV-Res064-In	Ductile Iron	500	104	110	FALSE	Open	16,500	0.97	0.25	2.41
P-575	FCV-Res064-In	Res-064	Ductile Iron	500	628	110	FALSE	Open	16,500	0.97	1.51	2.41
P-576	J-542	FCV-Res043-In	Steel	1,200	101	100	FALSE	Open	30,000	0.31	0.01	0.12
P-577	FCV-Res043-In	Res-043	Steel	1,200	18	100	TRUE	Open	30,000	0.31	0.00	0.12
P-578	J-431	FCV-Res055-In	Steel	900	4293	100	FALSE	Open	22,896	0.42	1.29	0.30
P-579	FCV-Res055-In	Res-055	Steel	900	112	100	FALSE	Open	22,896	0.42	0.03	0.30
P-58	FCV-Res056-In	Res-056	Concrete	1600	14	100	FALSE	Open	66,000	0.38	0.00	0.13
P-580	J-553	FCV-Res011-In	Concrete	1,200	36	100	FALSE	Open	80,159	0.82	0.03	0.75
P-581	FCV-Res011-In	Res-011	Concrete	1,200	997	100	TRUE	Open	80,159	0.82	0.75	0.76
P-582	J-322	FCV-Res008-In	Steel	900	117	100	FALSE	Open	127,865	2.33	0.85	7.28
P-583	FCV-Res008-In	Res-008	Steel	900	24	100	FALSE	Open	127,865	2.33	0.17	7.28
P-585	Res-053	FCV-Res053-Out	Steel	1,250	38	100	FALSE	Open	73,125	0.69	0.02	0.52
P-586	FCV-Res053-Out	J-231	Steel	1200	4,175	100	FALSE	Open	73,125	0.75	2.66	0.64
P-587	J-322	FCV-Res001-In-2	Concrete	1850	1867	100	FALSE	Open	119,875	0.52	0.36	0.19
P-588	FCV-Res001-In-2	Res-001	Concrete	1,850	22	100	FALSE	Open	119,875	0.52	0.00	0.20
P-6	CWT-095	CWT-097	Ductile Iron	1,600	1	110	FALSE	Open	140,819	0.81	0.00	0.45
P-604	J-218	J-217	Concrete	900	1,028	100	FALSE	Open	50,696	0.92	1.35	1.31
P-605	J-218-1	J-218	Concrete	900	225	100	FALSE	Open	50,696	0.92	0.30	1.31
P-606	J-303	J-304	Concrete	1,350	2266	100	FALSE	Open	180,005	1.46	4.31	1.90
P-607	J-302	J-303	Concrete	1,700	1200	100	FALSE	Open	204,619	1.04	0.94	0.79
P-608	J-351	J-350	Steel	700	1559	100	FALSE	Open	10,000	0.30	0.34	0.22
P-609	J-350	BS-104	Ductile Iron	400	976	110	FALSE	Open	10,000	0.92	2.76	2.83
P-610	J-271	J-272	Concrete	1600	41	100	FALSE	Open	310,250	1.79	0.09	2.28
P-611	J-272	PMP-056-2	Steel	1,400	1	100	FALSE	Open	63,750	0.48	0.00	0.30
P-612	J-272	PMP-056-1	Steel	1,600	1	100	FALSE	Open	246,500	1.42	0.00	1.49
P-614	J-420	Res-032	Ductile Iron	300	822	110	FALSE	Open	6,475	1.06	4.22	5.13
P-615	J-421	J-422	Ductile Iron	350	204	110	FALSE	Open	12,031	1.45	1.56	7.63
P-619	FCV-BS018-In	J-555	Steel	1250	2530	100	FALSE	Open	55,000	0.52	0.78	0.31
P-620	J-555	BS-017	Steel	1,250	1373	100	FALSE	Open	55,000	0.52	0.42	0.31
P-621	J-531	J-530	Steel	1400	3,936	100	FALSE	Open	147,119	1.11	4.32	1.10
P-622	J-530	J-543	Steel	1400	3,191	100	FALSE	Open	147,119	1.11	3.50	1.10
P-624	FCV-Res030-In	Res-030	Ductile Iron	300	34	110	FALSE	Open	4,657	0.76	0.09	2.79
P-626	J-472	J-473	Steel	1600	324	100	FALSE	Open	256,081	1.47	0.52	1.60
P-627	J-602	J-603	Steel	700	3,176	100	FALSE	Open	920	0.03	0.01	0.00
P-628	J-603	J-611	Ductile Iron	600	1,096	110	FALSE	Open	920	0.04	0.01	0.00
P-629	PMP-036	J-612	Steel	800	944	100	TRUE	Open	44,354	1.02	1.72	1.82
P-630	J-612	Res-063	Steel	700	1079	100	FALSE	Open	44,354	1.33	3.76	3.49
P-636	J-PMP-016-2	Res-051	Steel	900	4582	100	FALSE	Open	10,800	0.20	0.34	0.07
P-638	J-341	J-342	Steel	900	2008	100	TRUE	Open	22,909	0.42	0.61	0.30
P-639	WTP-5	CWT-099	Steel	2000	1	100	FALSE	Open	279,900	1.03	0.00	0.60
P-640	WTP-3	CWT-095	Steel	2000	1	100	FALSE	Open	401,199	1.48	0.00	1.19
P-641	WTP-4	CWT-097	Steel	2000	1	100	FALSE	Open	397,700	1.47	0.00	1.19
P-66	J-578	J-579	Steel	1,200	523	100	TRUE	Open	94,657	0.97	0.54	1.03
P-67	J-579	FCV-Res002-In-2	Steel	900	153	100	FALSE	Open	94,657	1.72	0.64	4.17
P-68	FCV-Res002-In-2	Res-002	Steel	900	24	100	FALSE	Open	94,657	1.72	0.10	4.17
P-70	PMP-002	J-992	Ductile Iron	900	128	110	TRUE	Open	48,470	0.88	0.13	1.01
P-72	J-451	J-452	Steel	1600	24	100	FALSE	Open	146,207	0.84	0.01	0.57
P-73	J-632	J-991	Steel	1,000	1,847	100	FALSE	Open	12,960	0.19	0.12	0.06
P-78	J-452	J-453	Steel	1,600	2135	100	FALSE	Open	122,388	0.70	0.87	0.41
P-79	J-461	J-462	Steel	1,600	2153	100	FALSE	Open	133,693	0.77	1.03	0.48
P-8	J-PMP-024	Res-032	Steel	500	1405	100	FALSE	Open	22,430	1.32	7.13	5.08
P-80	J-991	J-631	Steel	1,000	1141	100	FALSE	Open	71,162	1.05	1.68	1.47
P-81	J-453	J-471	Steel	1600	60	100	FALSE	Open	122,388	0.70	0.02	0.41

Section 2: Transmission Network Model
Table 2: Pipe Elements

Label	From Node	To Node	Material	Diameter (mm)	Length (m)	Hazen-Williams C	Check Valve?	Control Status	Discharge (m3/day)	Velocity (m/s)	Pipe Headloss (m)	Headloss Gradient (m/km)
P-82	J-462	J-471	Steel	1600	58	100	FALSE	Open	133,693	0.77	0.03	0.48
P-87	J-631	FCV-BS114-In	Steel	800	26	100	FALSE	Open	33,600	0.77	0.03	1.09
P-88	J-471	J-472	Steel	1600	971	100	FALSE	Open	256,081	1.47	1.55	1.60
P-89	FCV-BS114-In	BS-114	Steel	800	89	100	FALSE	Open	33,600	0.77	0.10	1.09
P-9	Res-032	J-421	Steel	450	855	100	FALSE	Open	19,228	1.40	5.45	6.38
P-90	BS-104	FCV-Res018-In	Ductile Iron	400	19	110	FALSE	Open	10,000	0.92	0.05	2.83
P-96	FCV-Res018-In	J-352	Ductile Iron	400	1203	110	FALSE	Open	10,000	0.92	3.40	2.83
P-97	J-492	FCV-Res020-In	Steel	1,200	2116	100	FALSE	Open	102,810	1.05	2.53	1.20
P-98	FCV-Res020-In	Res-020	Steel	1200	24	100	FALSE	Open	102,810	1.05	0.03	1.20
P-99	Res-026	FCV-Res028-In	Ductile Iron	400	1	110	FALSE	Open	10,971	1.01	0.00	3.42
P-PMP-802-1	PMP-802-1	Res-073	Steel	1,000	85	100	TRUE	Open	86,180	1.27	0.18	2.10
P-PMP-802-2	PMP-802-2	Res-073	Steel	1,000	78	100	TRUE	Open	113,920	1.68	0.27	3.52
P-PMP-803	PMP-803	Res-069	Steel	500	53	100	TRUE	Open	13,200	0.78	0.10	1.90
P-PMP-804	PMP-804	Res-068	Steel	1,000	65	100	TRUE	Open	8,400	0.12	0.00	0.03
P-PMP-805	PMP-805	CT-066	Steel	1,000	112	100	TRUE	Open	43,200	0.64	0.07	0.58
P-PMP-806	PMP-806	CT-065	Steel	1,000	79	100	TRUE	Open	12,960	0.19	0.00	0.06
P-PMP-807	PMP-807	Res-089	Steel	1,000	119	100	TRUE	Open	13,920	0.21	0.01	0.07
P-PMP-808	PMP-808	Res-036	Steel	1,000	44	100	TRUE	Open	32,640	0.48	0.02	0.35
P-PMP-809	PMP-809	Res-016	Steel	1,000	65	100	TRUE	Open	35,520	0.52	0.03	0.41
P-PMP-810	PMP-810	CT-052	Steel	1,000	61	100	TRUE	Open	146,250	2.16	0.34	5.59
P-PMP-811	PMP-811	Res-015	Steel	1,000	86	100	TRUE	Open	48,570	0.72	0.06	0.73
P-PMP-812	PMP-812	Res-013	Steel	1,000	50	100	TRUE	Open	75,060	1.11	0.08	1.63
P-PMP-813	PMP-813	CT-096	Steel	1,000	1094	100	TRUE	Open	63,300	0.93	1.30	1.19
P-PMP-814	PMP-814	Res-003	Steel	1,000	125	100	TRUE	Open	73,510	1.08	0.20	1.56
P-PMP-815	PMP-815	Res-004	Steel	1,000	111	100	TRUE	Open	21,120	0.31	0.02	0.16
P-PMP-816	PMP-816	Res-005	Steel	1,000	79	100	TRUE	Open	22,800	0.34	0.01	0.18
P-PMP-818	PMP-818	Res-031	Steel	1,000	118	100	TRUE	Open	13,200	0.19	0.01	0.06
P-PMP-820	PMP-820	Res-007	Steel	1,000	68	100	TRUE	Open	33,288	0.49	0.02	0.36
P-PMP-821	PMP-821	Res-007	Steel	1,000	70	100	TRUE	Open	36,062	0.53	0.03	0.42
P-PMP-822	PMP-822	Res-002	Steel	1,000	98	100	TRUE	Open	9,600	0.14	0.00	0.04
P-PMP-823	PMP-823	CWT-092	Steel	1,000	49	100	TRUE	Open	34,560	0.51	0.02	0.39
P-PMP-824	PMP-824	J-633	Steel	1,000	463	100	TRUE	Open	7,920	0.12	0.01	0.03
P-PMP-825	PMP-825	CWT-093	Steel	1,000	161	100	TRUE	Open	42,240	0.62	0.09	0.56
P-PMP-828	PMP-828	Res-021	Steel	1,000	91	100	TRUE	Open	12,000	0.18	0.00	0.05
P-PMP-831	PMP-831	Res-040	Steel	1,000	55	100	TRUE	Open	27,000	0.40	0.01	0.24
P-PMP-832	PMP-832	Res-019	Steel	1,000	87	100	TRUE	Open	16,800	0.25	0.01	0.10
P-PMP-833	PMP-833	Res-011	Steel	1,000	161	100	TRUE	Open	5,670	0.08	0.00	0.01
P-PMP-891	PMP-891	J-632	Steel	1,000	783	100	TRUE	Open	5,040	0.07	0.01	0.01
P-PMP-892	PMP-892	J-991	Steel	1,000	81	100	FALSE	Open	58,202	0.86	0.08	1.01
P-R3	WTP-3	R-3	Steel	1000	1	100	TRUE	Open	1	0.00	0.00	0.00
P-R5	WTP-5	R-5	Steel	1,000	1	100	FALSE	Open	0	0.00	0.00	0.00
P-Well-802-1	Well-802-1	PMP-802-1	Steel	1,000	1	100	FALSE	Open	86,180	1.27	0.00	2.08
P-Well-802-2	Well-802-2	PMP-802-2	Steel	1,000	1	100	FALSE	Open	113,920	1.68	0.00	3.50
P-Well-803	Well-803	PMP-803	Steel	500	1	100	FALSE	Open	13,200	0.78	0.00	1.93
P-Well-804	Well-804	PMP-804	Steel	1,000	1	100	FALSE	Open	8,400	0.12	0.00	0.07
P-Well-805	Well-805	PMP-805	Steel	1,000	1	100	FALSE	Open	43,200	0.64	0.00	0.60
P-Well-806	Well-806	PMP-806	Steel	1,000	1	100	FALSE	Open	12,960	0.19	0.00	0.07
P-Well-807	Well-807	PMP-807	Steel	1,000	1	100	FALSE	Open	13,920	0.21	0.00	0.07
P-Well-808	Well-808	PMP-808	Steel	1,000	1	100	FALSE	Open	32,640	0.48	0.00	0.37
P-Well-809	Well-809	PMP-809	Steel	1,000	1	100	FALSE	Open	35,520	0.52	0.00	0.45
P-Well-810	Well-810	PMP-810	Steel	1,000	1	100	FALSE	Open	146,250	2.16	0.01	5.58
P-Well-811	Well-811	PMP-811	Steel	1000	1	100	FALSE	Open	48,570	0.72	0.00	0.74
P-Well-812	Well-812	PMP-812	Steel	1,000	1	100	FALSE	Open	75,060	1.11	0.00	1.64
P-Well-813	Well-813	PMP-813	Steel	1,000	1	100	FALSE	Open	63,300	0.93	0.00	1.19
P-Well-814	Well-814	PMP-814	Steel	1,000	1	100	FALSE	Open	73,510	1.08	0.00	1.56
P-Well-815	Well-815	PMP-815	Steel	500	1	100	FALSE	Open	21,120	1.24	0.00	4.54
P-Well-816	Well-816	PMP-816	Steel	1,000	1	100	FALSE	Open	22,800	0.34	0.00	0.15
P-Well-818	Well-818	PMP-818	Steel	1,000	1	100	FALSE	Open	13,200	0.19	0.00	0.07
P-Well-820	Well-820	PMP-820	Steel	1,000	1	100	FALSE	Open	33,288	0.49	0.00	0.37
P-Well-821	Well-821	PMP-821	Steel	1,000	1	100	FALSE	Open	36,062	0.53	0.00	0.45
P-Well-822	Well-822	PMP-822	Steel	1,000	1	100	FALSE	Open	9,600	0.14	0.00	0.07
P-Well-823	Well-823	PMP-823	Steel	1,000	1	100	FALSE	Open	34,560	0.51	0.00	0.37
P-Well-824	Well-824	PMP-824	Steel	1,000	30	100	FALSE	Open	7,920	0.12	0.00	0.02
P-Well-825	Well-825	PMP-825	Steel	1,000	1	100	FALSE	Open	42,240	0.62	0.00	0.60
P-Well-828	Well-828	PMP-828	Steel	1,000	1	100	FALSE	Open	12,000	0.18	0.00	0.00
P-Well-831	Well-831	PMP-831	Steel	1,000	1	100	FALSE	Open	27,000	0.40	0.00	0.30
P-Well-832	Well-832	PMP-832	Steel	1000	23	100	FALSE	Open	16,800	0.25	0.00	0.10
P-Well-833	Well-833	PMP-833	Steel	1000	1	100	FALSE	Open	5,670	0.08	0.00	0.00
P-Well-891	Well-891	PMP-891	Steel	1000	1	100	FALSE	Open	5,040	0.07	0.00	0.00
P-Well-892	Well-892	PMP-892	Steel	1000	25	100	FALSE	Open	58,202	0.86	0.03	1.02

Section 2: Transmission Network Model
Table 3: Tanks/Reservoirs

Label	Elevation (m)	Base Elevation (m)	Maximum Elevation (m)	Minimum Elevation (m)	Initial HGL (m)	Total Active Volume (m3)	Base Flow (m3/day)	Outflow (m3/day)	Current Status	Calculated Hydraulic Grade (m)	Calculated Percent Full (%)
CT-052	1,151.00	1,146.00	1,151.00	1,146.30	1,150.00	20,000	0	0	Draining	1,150.00	78.7
ET-113	1,580.00	1,575.00	1,580.00	1,575.00	1,579.00	50	9,936	0	Draining	1,579.00	80.0
Res-003	1,239.00	1,234.00	1,239.00	1,234.50	1,238.00	55,500	0	0	Draining	1,238.00	77.8
Res-005	1,239.00	1,234.00	1,239.00	1,234.50	1,238.00	55,500	0	0	Draining	1,238.00	77.8
Res-008	1,307.00	1,302.00	1,307.00	1,302.33	1,306.00	55,500	125,885	0	Draining	1,306.00	78.6
Res-011	1,359.00	1,352.00	1,359.00	1,352.33	1,358.00	38,400	0	0	Draining	1,358.00	85.0
Res-019	1,444.00	1,439.00	1,444.00	1,439.30	1,443.00	20,500	125,976	0	Draining	1,443.00	78.7
Res-020	1,676.00	1,668.00	1,676.00	1,668.00	1,675.00	33,000	61,426	0	Draining	1,675.00	87.5
Res-022	1,522.00	1,517.00	1,522.00	1,517.30	1,521.00	37,000	0	0	Draining	1,521.00	78.7
Res-025	1,669.00	1,661.00	1,669.00	1,661.40	1,668.00	31,000	0	0	Draining	1,668.00	86.8
Res-036	1,132.00	1,132.00	1,137.00	1,132.30	1,132.31	43,700	81,182	0	Draining	1,132.31	0.2
Res-040	1,326.00	1,518.00	1,526.00	1,518.50	1,525.50	26,250	23,674	0	Draining	1,525.50	93.3
Res-071	1,509.00	1,502.00	1,509.00	1,502.80	1,503.00	20,000	37,078	0	Draining	1,503.00	3.2
Res-080	1,532.00	1,525.00	1,532.00	1,525.00	1,531.00	36,000	22,253	0	Draining	1,531.00	85.7
BPT-044	1,332.00	1,327.00	1,332.00	1,327.30	1,327.30	2,500	0	0	Empty	1,327.30	0.0
ET-109	1,680.00	1,675.00	1,680.00	1,675.00	1,675.00	500	0	0	Empty	1,675.00	0.0
ET-111	1,153.00	1,147.00	1,153.00	1,147.00	1,147.00	600	0	0	Empty	1,147.00	0.0
Res-054	1,307.00	1,302.00	1,307.00	1,302.00	1,302.00	34,000	0	0	Empty	1,302.00	0.0
Res-061	1,367.00	1,360.00	1,367.00	1,360.30	1,360.30	32,000	0	0	Empty	1,360.30	0.0
Res-077	1,838.00	1,833.00	1,838.00	1,833.50	1,833.50	10,000	0	0	Empty	1,833.50	0.0
BPT-076	1,364.00	1,359.00	1,364.00	1,359.00	1,363.50	2,400	0	0	Filling	1,363.50	90.0
Res-001	1,307.00	1,302.00	1,307.00	1,302.25	1,306.00	75,600	25920	0	Filling	1,306.00	78.9
Res-002	1,307.00	1,302.00	1,307.00	1,302.50	1,306.00	74,000	111,456	0	Filling	1,306.00	77.8
Res-004	1,239.00	1,234.00	1,239.00	1,234.50	1,238.00	55,500	0	0	Filling	1,238.00	77.8
Res-006	1,239.00	1,234.00	1,239.00	1,234.50	1,238.00	55,500	0	0	Filling	1,238.00	77.8
Res-013	1,239.00	1,233.00	1,239.00	1,233.75	1,238.00	55,500	0	0	Filling	1,238.00	81.0
Res-014	1,448.00	1,443.00	1,448.00	1,443.30	1,447.00	25,000	0	0	Filling	1,447.00	78.7
Res-015	1,163.00	1,157.00	1,163.00	1,157.75	1,162.99	55,500	0	0	Filling	1,162.99	99.8
Res-016	1,163.00	1,157.00	1,163.00	1,157.75	1,163.00	55,500	0	0	Filling	1,163.00	100.0
Res-021	1,526.00	1,521.00	1,526.00	1,521.30	1,525.00	27,000	51294	0	Filling	1,525.00	78.7
Res-031	1,239.00	1,234.00	1,239.00	1,234.30	1,238.00	37,000	15725	0	Filling	1,238.00	78.7
Res-034	1,440.00	1,437.50	1,442.00	1,437.60	1,441.00	7,700	12,787	0	Filling	1,441.00	77.3
Res-039	1,448.00	1,440.00	1,448.00	1,440.40	1,440.40	13,800	0	0	Filling	1,440.40	0.0
Res-043	1,477.00	1,469.00	1,477.00	1,469.40	1,476.00	44,000	10000	0	Filling	1,476.00	86.8
Res-056	1,324.00	1,316.00	1,324.00	1,316.40	1,323.00	26,800	0	0	Filling	1,323.00	86.8
Res-059	1,462.00	1,454.00	1,462.00	1,454.40	1,461.00	30,000	6907	0	Filling	1,461.00	86.8
Res-062	1,359.00	1,351.00	1,359.00	1,351.50	1,351.50	22,000	0	0	Filling	1,351.50	0.0
Res-063	1,239.00	1,231.00	1,239.00	1,231.50	1,238.00	10,000	0	0	Filling	1,238.00	86.7
Res-073	1,144.00	1,140.00	1,144.00	1,140.00	1,143.00	20,000	0	0	Filling	1,143.00	75.0
Res-089	1,090.00	1,084.00	1,090.00	1,084.20	1,089.00	20,000	13920	0	Filling	1,089.00	82.8
CT-065	1,096.00	1,092.00	1,096.00	1,092.00	1,095.00	19,000	0	0	Steady	1,095.00	75.0
CT-066	1,103.00	1,099.00	1,103.00	1,099.00	1,102.00	17,000	0	0	Steady	1,102.00	75.0
CT-096	1,214.00	1,209.00	1,214.00	1,209.50	1,213.00	2,700	0	0	Steady	1,213.00	77.8
ET-033	1,810.00	1,827.00	1,832.00	1,827.30	1,831.00	400	3800	0	Steady	1,831.00	78.7
ET-112	1,170.00	1,140.00	1,170.00	1,165.00	1,169.00	1,500	13,200	0	Steady	1,169.00	80.0
Res-007	1,307.00	1,302.00	1,307.00	1,302.33	1,306.00	55,500	76,982	0	Steady	1,306.00	78.6
Res-009	1,367.00	1,360.00	1,367.00	1,360.33	1,366.00	18,500	43,891	0	Steady	1,366.00	85.0
Res-010	1,359.00	1,352.00	1,359.00	1,352.33	1,358.00	36,500	48,470	0	Steady	1,358.00	85.0
Res-012	1,552.00	1,547.00	1,552.00	1,547.30	1,551.00	5,000	20,000	0	Steady	1,551.00	78.7
Res-018	1,417.00	1,412.00	1,417.00	1,412.25	1,416.00	2,500	11,980	0	Steady	1,416.00	78.9
Res-023	1,669.00	1,661.00	1,669.00	1,661.40	1,668.00	31,600	98,064	0	Steady	1,668.00	86.8
Res-024	1,665.00	1,657.00	1,665.00	1,657.40	1,664.00	34,000	14,256	0	Steady	1,664.00	86.8
Res-026	1,753.00	1,745.00	1,753.00	1,745.00	1,752.00	52,500	30,413	0	Steady	1,752.00	87.5
Res-027	1,753.00	1,745.00	1,753.00	1,745.40	1,752.00	12,000	23,921	0	Steady	1,752.00	86.8
Res-028	1,807.00	1,799.00	1,807.00	1,799.40	1,806.00	7,000	7,171	0	Steady	1,806.00	86.8
Res-029	1,807.00	1,799.00	1,807.00	1,799.00	1,806.00	6,700	4,879	0	Steady	1,806.00	87.5
Res-030	1,753.00	1,748.00	1,753.00	1,748.30	1,752.00	4,000	4,657	0	Steady	1,752.00	78.7
Res-032	1,807.00	1,802.00	1,807.00	1,802.30	1,806.00	22,200	0	0	Steady	1,806.00	78.7
Res-037	1,522.00	1,514.00	1,522.00	1,514.40	1,521.00	45,000	47779	0	Steady	1,521.00	86.8
Res-038	1,665.00	1,657.00	1,665.00	1,657.40	1,664.00	64,000	33,869	0	Steady	1,664.00	86.8
Res-041	1,582.00	1,574.00	1,582.00	1,574.40	1,581.00	27,500	16,330	0	Steady	1,581.00	86.8
Res-051	1,239.00	1,231.00	1,239.00	1,231.20	1,238.00	65,000	0	0	Steady	1,238.00	87.2
Res-053	1,163.00	1,157.00	1,163.00	1,157.80	1,162.99	33,000	0	0	Steady	1,162.99	99.8
Res-055	1,372.00	1,364.00	1,372.00	1,364.40	1,371.00	42,000	22,896	0	Steady	1,371.00	86.8
Res-057	1,392.00	1,384.00	1,392.00	1,384.40	1,391.00	47,000	64,368	0	Steady	1,391.00	86.8
Res-058	1,462.00	1,454.00	1,462.00	1,454.40	1,461.00	44,200	53,482	0	Steady	1,461.00	86.8
Res-064	1,171.00	1,166.00	1,171.00	1,166.50	1,170.00	16,500	16,500	0	Steady	1,170.00	77.8
Res-068	1,121.00	1,114.00	1,121.00	1,114.20	1,120.00	20,000	560	0	Steady	1,120.00	85.3
Res-069	1,140.00	1,133.00	1,140.00	1,133.20	1,139.00	20,000	0	0	Steady	1,139.00	85.3
Res-072	1,582.00	1,574.00	1,582.00	1,574.20	1,581.00	22,000	20,909	0	Steady	1,581.00	87.2
Res-074	1,669.00	1,661.00	1,669.00	1,661.50	1,668.00	10,000	9,139	0	Steady	1,668.00	86.7
Res-075	1,753.00	1,746.00	1,753.00	1,746.20	1,752.00	10,000	14,680	0	Steady	1,752.00	85.3
Res-081	1,602.00	1,597.00	1,602.00	1,597.50	1,601.00	20,000	34,590	0	Steady	1,601.00	77.8
Res-082	1,753.00	1,748.00	1,753.00	1,748.50	1,752.00	10,000	11,971	0	Steady	1,752.00	77.8
Res-091	1,877.00	1,872.00	1,877.00	1,872.50	1,876.00	12,000	9,677	0	Steady	1,876.00	77.8
Res-094	1,550.00	1,545.00	1,550.00	1,545.00	1,549.00	25,000	28,414	0	Steady	1,549.00	80.0

Table 4: Pumps

Label	Elevation (m)	Control Status	Intake Pump Grade (m)	Discharge Pump Grade (m)	Discharge (m3/day)	Pump Head (m)
BS-105	1,489.00	Off	1,514.50	1,532.75	0	0.00
PMP-001-3	1,302.00	Off	1,324.10	1,342.20	0	0.00
PMP-019	1,439.00	Off	1,498.77	1,517.37	0	0.00
PMP-021-1	1,521.00	Off	1,525.00	1,525.00	0	0.00
PMP-021-2	1,521.00	Off	1,525.00	1,525.00	0	0.00
PMP-034-2	1,437.00	Off	1,447.69	1,454.38	0	0.00
PMP-040	1,518.00	Off	1,570.64	1,585.69	0	0.00
PMP-068-2	1,114.00	Off	1,129.00	1,138.00	0	0.00
PMP-075	1,753.00	Off	1,779.17	1,806.33	0	0.00
PMP-817	1,104.00	Off	1,245.88	1,245.88	0	0.00
PMP-819	1,071.00	Off	1,489.20	1,489.20	0	0.00
PMP-827	1,393.00	Off	1,521.00	1,521.00	0	0.00
PMP-830	1,396.00	Off	1,581.00	1,581.00	0	0.00
BS-017	1,480.00	On	1,395.62	1,525.14	55,000	129.51
BS-104	1,324.00	On	1,444.16	1,534.16	10,000	90.00
BS-114	1,280.00	On	1,249.37	1,321.59	33,600	72.22
PMP-001-1	1,302.00	On	1,300.32	1,450.32	76,800	150.00
PMP-001-2	1,302.00	On	1,287.02	1,458.91	47,955	171.89
PMP-002	1,305.00	On	1,272.05	1,363.17	48,470	91.12
PMP-008	1,302.00	On	1,301.09	1,416.09	1,980	115.00
PMP-013	1,233.00	On	1,221.89	1,322.19	55,297	100.30
PMP-014-1	1,443.00	On	1,346.29	1,525.09	20,599	178.80
PMP-014-2	1,443.00	On	1,354.67	1,533.36	40,760	178.68
PMP-015	1,157.00	On	1,162.99	1,342.25	64,697	179.26
PMP-016-2	1,157.00	On	1,163.00	1,239.00	10,800	76.00
PMP-020	1,668.00	On	1,669.86	1,753.44	41,384	83.59
PMP-022-1	1,517.00	On	1,516.05	1,678.44	21,581	162.38
PMP-022-2	1,517.00	On	1,516.06	1,678.45	21,580	162.39
PMP-022-3	1,517.00	On	1,516.32	1,668.32	15,300	152.00
PMP-024	1,657.00	On	1,654.42	1,813.15	28,905	158.74
PMP-025	1,661.00	On	1,657.16	1,757.16	28,800	100.00
PMP-026	1,345.00	On	1,747.12	1,809.98	10,971	62.86
PMP-027	1,745.00	On	1,748.78	1,806.08	4,879	57.31
PMP-028	1,799.00	On	1,800.91	1,840.91	3,800	40.00
PMP-032	1,802.00	On	1,765.44	1,876.36	9,677	110.91
PMP-036	1,132.00	On	1,129.10	1,243.48	44,354	114.38
PMP-037	1,514.00	On	1,501.45	1,581.50	51,449	80.05
PMP-038	1,657.00	On	1,652.34	1,752.50	11,971	100.16
PMP-043	1,469.00	On	1,472.96	1,552.96	20,000	80.00
PMP-052-1	1,146.00	On	1,150.00	1,190.91	93,450	40.91
PMP-052-2	1,146.00	On	1,150.00	1,190.00	52,800	40.00
PMP-056-1	1,315.00	On	1,323.26	1,404.21	246,500	80.95
PMP-056-2	1,315.00	On	1,323.26	1,468.26	63,750	145.00
PMP-057	1,384.00	On	1,390.94	1,479.89	159,236	88.95
PMP-058	1,454.00	On	1,461.00	1,528.87	105,754	67.87
PMP-059	1,454.00	On	1,461.00	1,537.08	56,843	76.08

Table 4: Pumps

Label	Elevation (m)	Control Status	Intake Pump Grade (m)	Discharge Pump Grade (m)	Discharge (m3/day)	Pump Head (m)
PMP-065	1,092.00	On	1,095.00	1,166.11	12,960	71.11
PMP-066	1,099.00	On	1,102.00	1,162.00	43,200	60.00
PMP-068-1	1,114.00	On	1,110.24	1,160.24	7,840	50.00
PMP-069	1,133.00	On	1,135.16	1,169.16	13,200	34.00
PMP-071	1,502.00	On	1,501.39	1,551.39	28,414	50.00
PMP-072	1,574.00	On	1,563.33	1,664.14	30,540	100.81
PMP-073-1	1,140.00	On	1,143.00	1,168.31	108,300	25.31
PMP-073-2	1,140.00	On	1,143.00	1,168.00	91,800	25.00
PMP-074	1,661.00	On	1,660.89	1,752.16	14,680	91.27
PMP-080	1,525.00	On	1,531.00	1,611.69	34,590	80.69
PMP-092-1	1,239.00	On	1,227.47	1,307.47	30,800	80.00
PMP-092-2	1,239.00	On	1,248.43	1,317.33	30,800	68.90
PMP-093	1,322.00	On	1,310.39	1,450.49	12,787	140.09
PMP-095	1,502.00	On	1,510.00	1,589.81	9,936	79.81
PMP-096	1,209.00	On	1,213.00	1,243.22	63,300	30.22
PMP-802-1	994.00	On	1,023.18	1,143.18	86,180	120.00
PMP-802-2	964.00	On	1,018.27	1,143.27	113,920	125.00
PMP-803	956.00	On	1,024.10	1,139.10	13,200	115.00
PMP-804	1,016.00	On	1,025.00	1,120.00	8,400	95.00
PMP-805	933.00	On	942.07	1,102.07	43,200	160.00
PMP-806	946.00	On	950.00	1,095.01	12,960	145.00
PMP-807	970.00	On	964.01	1,089.01	13,920	125.00
PMP-808	1,017.00	On	1,027.33	1,132.33	32,640	105.00
PMP-809	995.00	On	1,047.94	1,163.03	35,520	115.08
PMP-810	985.00	On	1,035.34	1,150.34	146,250	115.00
PMP-811	978.00	On	988.05	1,163.05	48,570	175.00
PMP-812	1,065.00	On	1,073.08	1,238.08	75,060	165.00
PMP-813	1,034.00	On	1,044.30	1,214.30	63,300	170.00
PMP-814	1,071.00	On	1,103.20	1,238.20	73,510	135.00
PMP-815	1,081.00	On	1,128.02	1,238.02	21,120	110.00
PMP-816	1,077.00	On	1,103.01	1,238.01	22,800	135.00
PMP-818	1,089.00	On	1,098.01	1,238.01	13,200	140.00
PMP-820	1,121.00	On	1,132.89	1,306.02	33,288	173.14
PMP-821	1,121.00	On	1,131.74	1,306.03	36,062	174.29
PMP-822	1,197.00	On	1,206.00	1,306.00	9,600	100.00
PMP-823	1,084.00	On	1,131.24	1,256.24	34,560	125.00
PMP-824	1,124.00	On	1,140.14	1,260.14	7,920	120.00
PMP-825	1,148.00	On	1,163.68	1,323.68	42,240	160.00
PMP-828	1,388.00	On	1,395.01	1,525.01	12,000	130.00
PMP-831	1,346.00	On	1,355.51	1,525.51	27,000	170.00
PMP-832	1,260.00	On	1,268.01	1,443.01	16,800	175.00
PMP-833	1,171.00	On	1,303.00	1,358.00	5,670	55.00
PMP-891	1,100.00	On	1,120.13	1,260.13	5,040	140.00
PMP-892	1,110.00	On	1,130.09	1,260.09	58,202	130.00

Label	Elevation (m)	Diameter (mm)	Control Status	Discharge (m3/day)	From HGL (m)	To HGL (m)	Headloss (m)
FCV-CWT093-Out	1,234.00	1,200	Closed	0	1,323.37	1,323.15	0.00
FCV-J462-Out	1,585.00	700	Closed	0	1,643.99	1,594.87	0.00
FCV-Res007-In-1	1,306.00	900	Closed	0	1,322.13	1,314.07	0.00
FCV-Res007-Out	1,307.00	1,350	Closed	0	1,306.07	1,306.15	0.00
FCV-Res013-In	1,269.00	1,000	Closed	0	1,293.69	1,265.84	0.00
FCV-Res019-In-2	1,439.00	1,200	Closed	0	1,492.58	1,467.79	0.00
FCV-Res019-Out	1,439.00	500	Closed	0	1,461.59	1,480.18	0.00
FCV-Res021-Out-1	1,521.00	1,200	Closed	0	1,525.00	1,525.00	0.00
FCV-Res021-Out-2	1,521.00	1,000	Closed	0	1,525.00	1,525.00	0.00
FCV-Res040-Out-2	1,518.00	700	Closed	0	1,540.55	1,555.59	0.00
FCV-Res074-In-2	1,661.00	500	Closed	0	1,677.81	1,672.90	0.00
FCV-J490-Out	1,480.00	1,200	Inactive	29,110	1,525.13	1,525.13	0.00
FCV-J-522-In-2	1,300.00	250	Inactive	4,000	1,474.10	1,474.10	0.00
FCV-Res003-Out	1,234.00	1,100	Inactive	77,390	1,237.99	1,237.99	0.00
FCV-Res004-Out	1,233.00	1,000	Inactive	65,135	1,237.99	1,237.98	0.00
FCV-Res005-Out	1,234.00	500	Inactive	89,980	1,237.99	1,237.99	0.00
FCV-Res006-In-1	1,239.00	900	Inactive	90,485	1,238.04	1,238.04	0.00
FCV-Res006-Out	1,234.00	1,100	Inactive	97,838	1,237.99	1,237.99	0.00
FCV-Res013-Out	1,233.00	500	Inactive	19,763	1,238.00	1,238.00	0.00
FCV-Res021-In-4	1,520.00	1,250	Inactive	25,890	1,525.00	1,525.00	0.00
FCV-Res021-In-5	1,521.00	1,000	Inactive	3,327	1,525.00	1,525.00	0.00
FCV-Res037-In	1,514.00	1,200	Inactive	99,228	1,521.01	1,521.01	0.00
FCV-Res051-Out	1,231.00	1,100	Inactive	124,126	1,237.99	1,237.99	0.00
FCV-016-053	1,157.50	1,200	Throttling	20,325	1,163.00	1,162.99	0.01
FCV-BPT076-In	1,364.00	800	Throttling	103,326	1,475.62	1,363.86	111.76
FCV-BS018-In	1,400.00	1,200	Throttling	55,000	1,480.76	1,396.82	83.94
FCV-BS114-In	1,248.60	800	Throttling	33,600	1,258.30	1,249.46	8.83
FCV-CT065-Out	1,092.00	1,000	Throttling	12,960	1,166.11	1,154.73	11.38
FCV-CT066-Out	1,099.00	900	Throttling	43,200	1,161.95	1,157.77	4.18
FCV-CT096-Out	1,209.00	1,000	Throttling	63,300	1,243.19	1,238.81	4.38
FCV-CWT092-Out	1,239.00	1,000	Throttling	30,800	1,256.23	1,248.43	7.79
FCV-ET033-In	1,799.00	150	Throttling	3,800	1,805.94	1,800.96	4.98
FCV-ET112-In	1,133.00	500	Throttling	13,200	1,138.97	1,135.18	3.79
FCV-ET113-In	1,502.00	500	Throttling	9,936	1,589.78	1,579.02	10.76
FCV-J271-Out-1	1,315.00	1,600	Throttling	246,500	1,404.17	1,394.10	10.07
FCV-J271-Out-2	1,315.00	1,400	Throttling	63,750	1,468.26	1,461.75	6.51
FCV-J522-In-1	1,300.00	300	Throttling	6,000	1,482.45	1,474.13	8.32
FCV-J554-Out	1,402.00	900	Throttling	70,000	1,480.75	1,346.34	134.41
FCV-Res001-In-1	1,239.00	800	Throttling	30,800	1,256.22	1,227.48	28.75
FCV-Res001-In-2	1,304.00	1,700	Throttling	119,875	1,317.72	1,306.00	11.71
FCV-Res001-Out-1	1,302.00	900	Throttling	76,800	1,306.00	1,300.32	5.68
FCV-Res001-Out-2	1,302.00	700	Throttling	47,955	1,306.00	1,287.02	18.97
FCV-Res002-In-1	1,305.00	900	Throttling	55,669	1,310.70	1,306.04	4.66
FCV-Res002-In-2	1,305.00	900	Throttling	94,657	1,329.23	1,306.10	23.13
FCV-Res003-In	1,239.00	900	Throttling	3,880	1,256.21	1,238.00	18.21
FCV-Res004-In	1,239.00	900	Throttling	44,015	1,248.01	1,238.01	10.00
FCV-Res005-In	1,239.00	900	Throttling	67,180	1,243.11	1,238.03	5.09
FCV-Res006-In-2	1,239.00	700	Throttling	7,353	1,310.74	1,238.00	72.74
FCV-Res007-In-2	1,306.00	1,200	Throttling	7,632	1,442.96	1,306.00	136.96
FCV-Res008-In	1,305.00	900	Throttling	127,865	1,317.23	1,306.17	11.05
FCV-Res008-Out	1,302.00	500	Throttling	1,980	1,306.00	1,301.09	4.91
FCV-Res009-In	1,364.00	900	Throttling	43,891	1,447.23	1,366.02	81.21
FCV-Res010-In	1,305.00	900	Throttling	48,470	1,305.98	1,272.08	33.90
FCV-Res011-In	1,411.00	1,200	Throttling	80,159	1,485.61	1,358.75	126.86
FCV-Res012-In	1,469.00	600	Throttling	20,000	1,476.00	1,472.96	3.04
FCV-Res013-Out-1	1,239.00	1,200	Throttling	55,297	1,238.00	1,221.89	16.11
FCV-Res014-Out-1	1,443.00	900	Throttling	20,599	1,447.00	1,346.29	100.71

Label	Elevation (m)	Diameter (mm)	Control Status	Discharge (m3/day)	From HGL (m)	To HGL (m)	Headloss (m)
FCV-Res014-Out-2	1,443.00	600	Throttling	40,760	1,446.99	1,354.68	92.32
FCV-Res015-Out	1,157.00	1,100	Throttling	64,697	1,342.25	1,239.96	102.29
FCV-Res016-In	1,163.00	900	Throttling	80,362	1,208.51	1,163.02	45.49
FCV-Res016-Out	1,157.00	1,250	Throttling	178,207	1,162.96	1,162.95	0.01
FCV-Res018-In	1,324.00	400	Throttling	10,000	1,534.11	1,420.06	114.05
FCV-Res019-In	1,440.00	1,200	Throttling	116,808	1,496.77	1,443.04	53.74
FCV-Res020-In	1,680.00	1,200	Throttling	102,810	1,685.41	1,675.03	10.38
FCV-Res021-In-1	1,561.00	1,200	Throttling	5,577	1,690.73	1,525.00	165.73
FCV-Res021-In-2	1,561.00	1,000	Throttling	4,500	1,690.74	1,525.00	165.73
FCV-Res022-In-1	1,520.00	1,200	Throttling	6,526	1,521.87	1,521.00	0.87
FCV-Res022-In-2	1,514.00	1,200	Throttling	20,000	1,523.90	1,521.06	2.84
FCV-Res022-In-3	1,515.00	1,200	Throttling	31,935	1,524.01	1,521.00	3.01
FCV-Res022-Out-1	1,517.00	500	Throttling	21,581	1,521.00	1,516.06	4.94
FCV-Res022-Out-2	1,517.00	500	Throttling	21,580	1,521.00	1,516.07	4.93
FCV-Res022-Out-3	1,517.00	600	Throttling	15,300	1,521.00	1,516.33	4.67
FCV-Res023-In	1,662.00	900	Throttling	98,064	1,682.50	1,668.06	14.44
FCV-Res025-In	1,666.00	900	Throttling	28,800	1,687.82	1,668.01	19.80
FCV-Res026-In	1,668.00	700	Throttling	41,384	1,675.00	1,669.86	5.14
FCV-Res027-In	1,661.00	600	Throttling	28,800	1,668.00	1,657.16	10.83
FCV-Res028-In	1,753.00	400	Throttling	10,971	1,752.00	1,747.12	4.88
FCV-Res029-In	1,745.00	500	Throttling	4,879	1,752.00	1,748.78	3.22
FCV-Res030-In	1,750.00	500	Throttling	4,657	1,795.36	1,752.09	43.26
FCV-Res031-In	1,234.00	1,250	Throttling	132,653	1,298.17	1,238.01	60.16
FCV-Res032-In	1,657.00	800	Throttling	28,905	1,664.00	1,654.42	9.58
FCV-Res034-In	1,322.00	400	Throttling	12,787	1,323.58	1,310.40	13.18
FCV-Res036-In	1,137.00	900	Throttling	92,896	1,132.38	1,132.38	0.00
FCV-Res040-Out-1	1,518.00	1,200	Throttling	3,327	1,525.50	1,525.01	0.49
FCV-Res041-In	1,582.00	500	Throttling	16,330	1,690.66	1,581.01	109.65
FCV-Res043-In	1,472.00	1,200	Throttling	30,000	1,492.23	1,476.00	16.23
FCV-Res051-In	0.00	500	Throttling	10,800	1,239.00	1,238.34	0.65
FCV-Res051-In-1	1,239.00	300	Throttling	10,000	1,369.53	1,238.08	131.44
FCV-Res051-In-2	1,237.00	800	Throttling	103,326	1,282.32	1,238.25	44.07
FCV-Res052-Out-1	0.00	1,200	Throttling	93,450	1,190.88	1,164.39	26.48
FCV-Res052-Out-2	1,151.00	1,200	Throttling	52,800	1,189.99	1,163.35	26.64
FCV-Res053-Out	1,360.00	1,250	Throttling	73,125	1,162.97	1,155.16	7.81
FCV-Res055-In	1,371.00	700	Throttling	22,896	1,389.67	1,371.03	18.63
FCV-Res056-In	1,322.00	1,600	Throttling	66,000	1,323.35	1,323.00	0.35
FCV-Res058-In	1,384.00	1,600	Throttling	159,236	1,479.87	1,463.32	16.56
FCV-Res058-Out	1,454.00	1,600	Throttling	105,754	1,528.86	1,522.64	6.21
FCV-Res063-In	1,132.00	800	Throttling	44,354	1,132.31	1,129.10	3.21
FCV-Res063-Out	1,230.00	600	Throttling	44,354	1,237.94	1,237.94	0.00
FCV-Res064-In	1,215.00	500	Throttling	16,500	1,220.11	1,171.51	48.60
FCV-Res068-Out	1,114.00	700	Throttling	7,840	1,120.00	1,110.24	9.76
FCV-Res071-In	1,508.00	700	Throttling	65,492	1,509.99	1,503.01	6.99
FCV-Res072-In	1,514.00	1,400	Throttling	51,449	1,521.00	1,501.45	19.55
FCV-Res072-Out	1,574.00	1,200	Throttling	30,540	1,581.00	1,563.33	17.67
FCV-Res073-Out-1	1,140.00	1,200	Throttling	108,300	1,168.26	1,167.49	0.77
FCV-Res073-Out-2	1,140.00	1,200	Throttling	91,800	1,167.96	1,166.28	1.68
FCV-Res074-In-1	1,638.00	900	Throttling	23,819	1,693.98	1,668.24	25.74
FCV-Res075-In	1,661.00	900	Throttling	14,680	1,668.00	1,660.89	7.11
FCV-Res080-In	1,454.00	1,400	Throttling	56,843	1,537.08	1,531.47	5.61
FCV-Res081-In	1,525.00	1,000	Throttling	34,590	1,611.67	1,601.49	10.18
FCV-Res082-In	1,657.00	700	Throttling	11,971	1,664.00	1,652.34	11.66
FCV-Res091-In	1,802.00	400	Throttling	9,677	1,806.00	1,765.45	40.55
FCV-Res094-In	1,502.00	700	Throttling	28,414	1,503.00	1,501.40	1.60